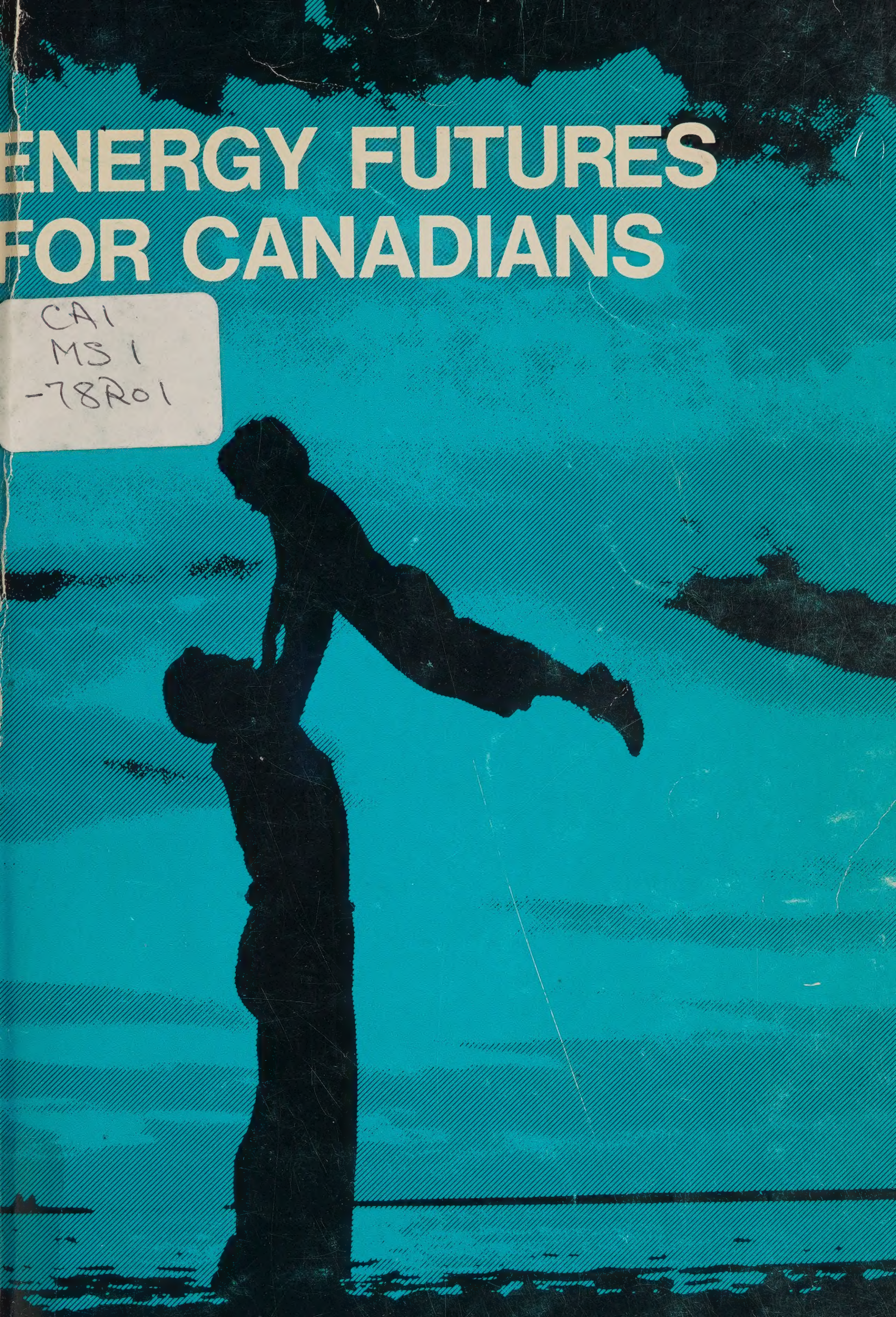
ENERGY FUTURES FOR CANADIANS



Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Report EP 78-1

ENERGY FUTURES FOR CANADIANS

Long-Term Energy Assessment Program (LEAP)

James E. Gander and Fred W. Belaire

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Letter of transmittal

June 12, 1978

The Honourable Minister
Department of Energy, Mines and Resources
Government of Canada
O T T A W A

Dear Mr. Minister:

I have the pleasure to transmit herewith the report, "Energy Futures for Canadians", which I was commissioned by Energy, Mines and Resources Canada to prepare. The report contains an assessment of Canada's energy prospects beyond 1990, and of the policies and programs which might be considered at this time, in addition to current initiatives, to take advantage of the available time for adjustment.

The report is subtitled "Long-term Energy Assessment Program" (LEAP). The subtitle is in recognition of the opportunity and the need to establish in Canada a continuing, systematic long-term energy assessment program.

I want to take this opportunity to record that I received the fullest cooperation from all officials of the Department who were called upon for assistance. Their cooperation and forbearance made an essential contribution. It is not possible to acknowledge individually the many contributions, but the continual, excellent advice of Dr. J. Walsh and Dr. P. Dyne was especially helpful. The conscientious efforts of the Word Processing Unit and of Publications and Translation should also be noted.

Liaison was established with 20 other departments and agencies of the federal government. Liaison was also established with, and visits made to, officials of all 10 provincial governments, as well as to many provincial agencies. In addition, numerous contacts were made with industry officials, universities, research centres, labour unions and special interest groups. The kind cooperation of all of these people, who gave so freely of their time, is gratefully acknowledged.

I also wish to record my appreciation of the dedicated service of my colleagues of the Energy Review Group: F. Belaire, J. Ringrose (Secretary) and to R.F.S. Robertson and I. Plaunt who were assigned for a time to the project.

The widespread interest and support which was shown during the preparation of this report suggests that Canadians are becoming increasingly aware of the serious energy problems which face this country and the world in the future, and of the need for concerted action now to overcome those problems.

Yours truly,

James E. Gander,
Director General,
Energy Review Group.

Foreword

In recent years the government has published two energy policy studies, one in 1973 just before rapid increases in the world oil price, and one in 1976 entitled "An Energy Strategy for Canada: Policies for Self-Reliance". Policy actions stemming from this document to reduce consumption, increase efficiency in energy use, accelerate domestic supply and reduce increasing reliance on imported oil, have followed. Although the forecasts made in 1976 would be modified to some extent if made today, the document remains basically sound and can continue to be used for planning purposes out to 1985 or 1990.

What now is needed is a longer term assessment beyond the year 2000 to 2025 and I accordingly commissioned the authors to prepare a long-term independent assessment of this more distant period. The resulting document, "Energy Futures for Canadians", is one view of this uncertain 50-year period in Canada's future. While the authors have had full access to both public and confidential material within my Department, and, in fact, worked on special assignment within the Department, they received no specific direction respecting the contents of the report and have been entirely free to reach their own conclusions, not only with respect to our energy future but also in recommending the actions they see as necessary to meet that future. They were encouraged to consult not only with government officials knowledgeable in the energy field but also with provincial and industry representatives as well as special interest groups, academics and members of the general public. They were asked to include as an appendix a summary of recent government policy actions so that the reader could judge what further actions might be appropriate.

I am pleased to support the publication of this report and commend it to all Canadians concerned with our energy future. While it does not represent a formal government view of the long-term future nor of the solutions required to meet the challenge, it has been carefully researched and presents a credible base case scenario. In examining the report, however, readers may want to make their own judgments as to alternative scenarios.

There can be no doubt that the report comes down on the somber side in assessing the future world energy situation, a perspective with which I agree. However, I am encouraged that we in Canada are fortunate in having a large and diversified resource

base including fossil fuels which can be developed at a price to meet our needs. What mix of energy sources and at what rate they will be required are questions that must be answered. We are called upon to reach agreement on long-term priorities over a wide range of activities. At the same time, those priorities must retain flexibility and resilience to accommodate rapidly changing circumstances, not just in energy but in the economy and even in the aspirations of Canadians. The value of this kind of report is not to "fix" the long-term future, but to help Canadians choose and develop satisfactory energy futures. Its greatest value, I believe, will be as an important contribution to the public dialogue and debate that must take place if we are to make the best choices from among the many alternatives available.

Honourable Alastair Gillespie,

Minister of Energy, Mines and Resources Canada

Preface

No one can forecast the future with any accuracy. What we can do is explore what might happen, and the implications of those developments on personal and community well-being. In a long view of the future, the twists and turns of current happenings need not cloud fundamental issues. Basic, underlying transitions can stand out more clearly, and common perceptions emerge concerning what actions should be taken to deal with those transitions. The more profound the anticipated changes, the longer typically will be the advance time needed to deal satisfactorily with them.

This study, like many others, points to extremely difficult energy transitions. One other recent study offers an especially useful comparison. The World Energy Conference, in a recent report, "World Energy: looking ahead to 2020" gives a world view for much the same period as this "Futures" report, based on a substantial amount of analysis and expert opinion. The Conference itself is a permanent organization which has followed world energy developments since 1924.

The estimated growth in world energy demand in this Futures report, although well within the range presented by the World Energy Conference, is somewhat higher than that favoured by the Conference. However, the growth rate for Canada in this Futures report is at the lower end of the Conference estimates for OECD countries. On the supply side, the World Energy Conference maintains a higher share for oil and natural gas, and a greater contribution from hydro power and other renewables (solar, wind, biomass, etc.) than used in this report. Lower shares are there recorded for nuclear fission and, especially for coal. The perceptions of the difficulties ahead and of the strategies are very similar in the two assessments. Among the strategies in the Conference report are:

- conservation through more efficient use of energy;
- maximum production of non-renewable resources such as coal, oil, gas and fissile nuclear resources;
- significant development of non-conventional oil and gas (oil sands, oil shales, etc.); and
- timely development of renewable resources (including nuclear fusion).

Societies, for the most part, have not been well equipped to serve, in a well-coordinated way, long-term objectives. A

capacity to do so seems increasingly necessary in the face of potentially very disruptive forces. This report is designed to extend, in a comprehensive, systematic way, the national dialogue on Canada's long-term future under the impact of extremely difficult energy transformations.

James E. Gander
Fred W. Belaire

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Part I

INTRODUCTION – TRANSITIONS TO A NEW ERA

Chapter 1. MEETING URGENT LONG-TERM NEEDS

Getting to 1978

In 1973, the world crossed the threshold from low-priced energy to high-priced energy and from one way of life to another. Throughout the preceding 25 years, a principal concern had been to find markets for abundant energy supplies, and to ensure that prices were low enough to encourage rapid expansion of the use of oil, natural gas and electricity. Now, five years after the 1973-74 crisis, great uncertainty remains concerning the nature and magnitude of the energy transition. Many countries continue in extremely difficult circumstances, even while more and more is being said about reduced rates of growth in energy demand and emerging surpluses in energy supply.

Many initiatives are being taken in Canada and abroad to cope with the changing circumstances. However, the basic problems remain. The shape of the new era is uncertain, except for a foreboding that the future rests on a very precarious energy situation.

The change in the world energy order was signalled by the Organization of Petroleum Exporting Countries (OPEC) in 1973-74 when the price of oil in the Persian Gulf was raised from $2.20 per barrel to $11.50 per barrel. Further increases followed, but the early increases already marked a permanent change in the world energy situation and outlook.

What changed in 1973?

In 1973, nothing suddenly happened to the world's supply of oil. What changed drastically were the conditions under which oil would be made available from the main sources of supply. After a decade of existence, the Organization of Petroleum Exporting Countries had reached a time for decisive action. Two conditions favoured action at that time. Hostilities in the Middle East encouraged some of the principal suppliers to use oil as a political bargaining counter. The United States was becoming an importer of increasingly large quantities of OPEC oil, thereby greatly increasing the bargaining power of the oil exporters. Imports of crude oil, which in 1955 had been only about 10 per cent of United States' supply, had risen by 1972 to nearly 24 per cent. They jumped to 35 per cent in 1973 and to nearly 40 per cent in 1974, as production in the United States declined from its 1970 peak. Only 15 years earlier, the United States had accounted for nearly one-half of world oil production; by 1973, it supplied only about 20 per cent, and the OPEC countries supplied more than 50 per cent (Figure 1-1).

Thus, the price increase of 1973 signalled a fundamental change, and that a very serious, long-term energy problem had come about. Several things became apparent:

- The shock waves from higher oil prices were immense and worldwide.

- The change was no temporary disturbance; it was here to stay; the effects would continue to spread throughout the world; it was a device that could be used again and again.

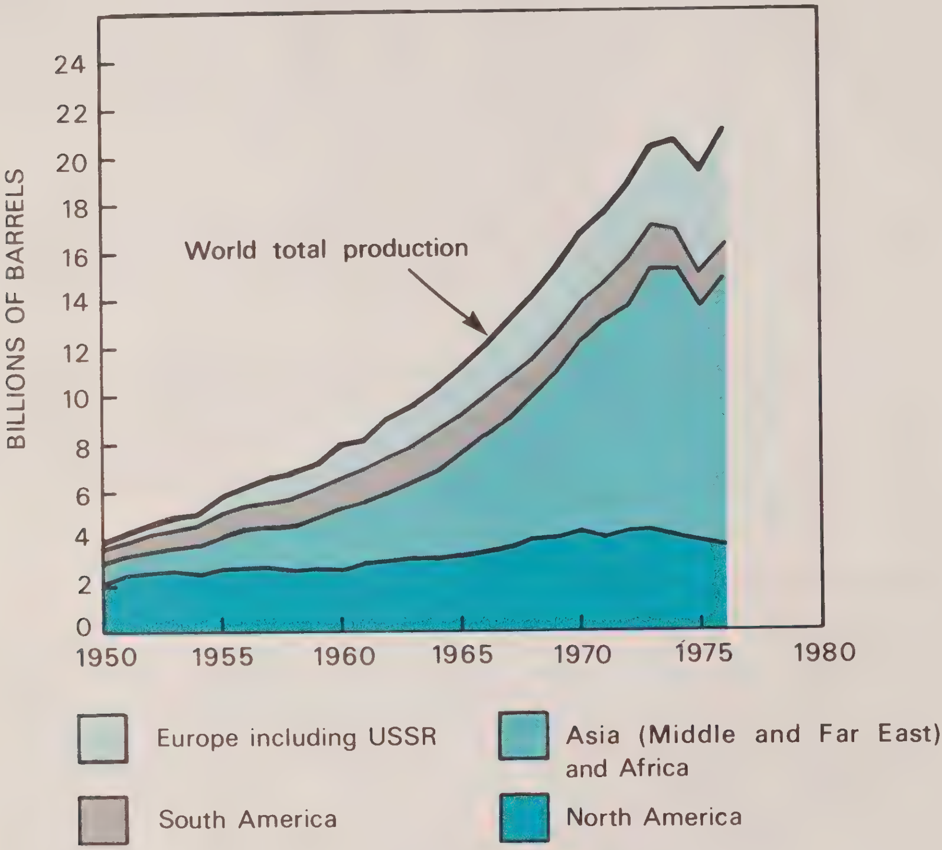

Figure 1-1. World crude oil production.

- The available supply of oil had shifted dramatically to the OPEC countries; its long-term availability would become increasingly uncertain in the face of substantial increases in demand; no ready substitutes for oil were available.

- Higher prices encouraged reductions in demand, but the reductions would be inequitable and not adequate in terms of the long-term availability of oil.

- The higher oil prices caused serious balance of payments difficulties for many countries heavily dependent on imported oil.

- The sharply increased revenues for oil exporting countries greatly changed the distribution of income and caused grave concern for the stability of the world's monetary system, in part because of the strain imposed upon developing countries with already insufficient foreign earnings.

- The higher oil prices added one more significant element to world inflationary pressures and to world economic recessionary pressures.

Two questions immediately arose:

"How can world dependency on oil be reduced?"

"By how much, how quickly?"

Canada and the higher oil prices

Canada, with its own supply of oil and other fuels, could stand back a little from the crisis, but not very far. Too many ramifications of the oil crisis affected, and continue to affect, Canada as well. In the first instance, any major disturbance in the world economic system must be a matter of serious concern to a country so dependent on international trading and finance. Oil prices in Canada also had to be re-considered. They were certain to increase, but by how much and how quickly? Export controls on oil could relieve the Canadian supply situation, but at the cost of export earnings. A levy on the price of oil exports could be used to moderate the rate of increase of the price of imported oil, so essential in eastern Canada, but that solution could only be short term, and would cause disputes within Canada. The international trade and balance of payments effects were cushioned by price increases for natural gas exports. However, higher revenues opened the way for increased taxes and royalties and created great uncertainty about the distribution of revenues and the longer term availability of gas in Canada.

The effects spread well beyond oil and the price of its products (for example, gasoline and home heating oil). Electricity generating plants, especially those in the Atlantic Provinces, found their fuel costs rising sharply, and they had to increase electricity rates to protect their financial capability. Electric utilities, which for years had been promoting greater use of

electricity, suddenly found themselves urging people to conserve. Gas utilities, once keen competitors of electric utilities, became quieter in their promotional efforts. Speed limits were reduced on some highways. Industries were asked to study thoroughly ways to increase energy efficiency, and householders were told of ways to reduce their use of energy and so avoid some of the higher costs. Electric light switches have not been so carefully managed since the Depression of the 1930s.

The 1985 Syndrome

Some of the urgency of the world energy adjustment appears to have eased as rates of growth in demand have moderated (during years of low economic advance) and as new sources of supply come on stream. Three or four years of relative ease in energy supplies might occur in the immediate future. Thus, assessments which are concerned with the world energy situation from now to 1985 might conclude that no great shortage will occur in world oil and that the real price of oil (i.e., in relation to price increases generally) will not increase and probably even decline. In those assessments, no serious difficulties are foreseen -- at least before 1985.

The conclusion of a comparatively easy energy supply situation to 1985 results from the anticipated, further moderation in rates of growth in world oil demand; the increased production and export capabilities of the OPEC countries; increasing oil production from the North Sea, the Alaskan North Slope, Mexico, and perhaps from other discoveries. Natural gas also will become available in increasing quantities, particularly in North Africa and the Middle East, and will enter international trade as liquefied natural gas (LNG). Taken altogether, therefore, that kind of assessment can conclude (perhaps quite correctly) that oil will be in a relatively easy supply situation until 1985 or even to 1990. Acceptance of that medium-term assessment blunts the enthusiasm for early action on adjustment programs. The view can readily be taken that energy adjustments will occur, as in the past, fairly smoothly and automatically, essentially in response to the usual forces of supply, demand and price.

That passive approach to the world energy future is here referred to as the 1985 Syndrome -- a public attitude of little concern, an attitude that can appreciably increase later difficulties.

What lies beyond that 1978-85 phase? Substantial energy transformations seem to confront virtually all countries. The next few years, during which traditional energy supplies will remain perhaps adequate, can be used as valuable lead time to begin to deal with the very difficult, longer term transformations. Once those transformations are well in place, perhaps by

about the turn of the century, subsequent adjustments can consolidate them and extend them, in a dynamic way, into new directions. An essential first requirement for the long-term future is to reduce considerably the world's dependence on oil as the dominant energy base.

Thus, this report deals with three principal time frames in which energy futures will overlap and continually change. These are:

1978-1985 - Putting the adjustments in place;

1978-2000 - Meeting the oil situation;

2000-2025 - Living in the new transitional age.

Putting adjustments in place, 1978-1985 (and beyond)

The adjustment process is outlined later in this chapter (and in Chapters 8 to 12) within a Canadian context. Although the transformations will be very difficult to achieve, they also offer great opportunities. To be on the edge of perceived transitions is to be at the frontiers of opportunity. In looking at the energy transformations, the report also touches on some of the opportunities for Canada as a whole and for regions, provinces and localities.

Important beginnings into the transitional era already are being made. These include, for example, conservation measures, increases in energy efficiency, efforts to protect Canadian energy supplies and to discover and develop new sources of supply; to evolve the technological innovations and the institutional, regulatory and management systems to moderate energy demands and to increase supplies. A number of the initiatives of the federal government are outlined in Appendix 4, and referred to throughout the report. In addition, the important roles of the provincial governments, of the multinational companies, of the small, Canadian companies, of public utilities, of foreign sources of funds, of ownership and control are receiving increasing attention. International consultation on the serious energy problems has been greatly stepped up. The complex problems of the environment, land-use, land ownership and local rights are being addressed, and modifications are continuously taking place in federal-provincial relations in energy-related matters. International energy trade, regional equity, pricing and financing problems are all high on the nation's agenda.

The steps which are being taken in many parts of Canada to deal with the changed energy situation demonstrate a continuing capacity for adjustment and resiliency. The steps so far taken, quite naturally, deal incrementally with an immediate problem, or

move ahead, on a project-by-project basis, within the framework of perceived needs and strategies for the coming 5 to 15 years. These short-term and medium-term incremental steps are the way in which changes typically are introduced. However, confronted with the magnitude of the transformations now ahead, our society (in common with others) is called upon to grapple with a third time dimension -- the longer term future. Fundamental modifications to the energy support system and to attendant economic and social conditions will be so profound that they require 20 to 50 years to implement. The long-term adjustment process is concerned with far more than energy supply and demand. It is concerned also with changes in institutions, organization and management, with pricing, financing, ownership, environmental impacts and a host of other adjustments. In addition, assessments are needed of the economic and social constraints and opportunities which will evolve around the new energy activities. Because of the magnitude and the rapidity with which further energy crises could disrupt our progress, we need to use all of the time which is now available to deal with the long-term transformations. The long-term future is urgent.

Meeting the oil situation, 1978-2000

The world oil situation is expected to deteriorate sharply after 1985 (Chapter 2). It is likely to reach a condition, possibly before 1990, when reliance on imported oil should be reduced to the minimum. By 1985, perhaps before or soon after, world oil prices are expected to increase substantially. Disruptions in world oil supply will become increasingly probable. The supply shortfalls and the increases in the price of oil will induce reductions in energy demand and provide scope for bringing on stream a diverse array of domestic energy resources.

Canada has the resources to achieve a position of sustainable self-reliance in energy by about the year 2000. Oil and other energy resources would be imported when availability and price justify imports on economic grounds. Imported oil probably would not provide more than 10 or 15 per cent of Canada's total oil requirements. Under those circumstances, oil imports would be smaller in quantity than they are at present. Oil imports, by the year 2000 or soon after, would not be an essential component in Canada's sustained energy balance. That objective is difficult to the point of being perhaps just barely achievable.

This objective of energy self-reliance by no means represents an isolationist position by Canada in world energy affairs (Chapter 3). In the first instance, exports and imports of energy and of international capital for energy projects will, in total, increase. In addition, Canada can use its energy base to gain access to world markets for its energy-intensive and

energy-related goods and services. It will not, however, be a substantial supplier of oil or natural gas to other countries. Canada will take part in international energy research and development (R&D) programs, and other international energy activities. By relying on its own resources, Canada will place less pressure on world energy supplies to the advantage of those countries much more dependent on those resources. The enterprise, lessons and skills called forth in Canada to meet its own energy requirements can be put at the disposal of developing countries to help them meet their energy futures. Major, new international programs are anticipated in relation to the energy transformations of the developing countries. The knowledge and skills can also be sold internationally.

To disagree with this assessment, in terms of the timing of the deterioration in the world oil situation, is not to invalidate the need for adjustment away from world oil. There might be an additional 5 or 10 years of available time. So much the better. The adjustment process is so massive that all possible available lead time is an advantage. However, most of that transformation in the basic energy system should be targetted to take place between now and the year 2000 -- an extremely short period of time. Well before 1985, the staging in of longer term programs should be well underway, but with flexibility to adjust to new circumstances and to new perceptions of the longer term future.

Living in the new transitional age, 2000-2025

Reductions in demand and increases in the efficiency with which energy is used (Chapter 4) will be matched in Canada, in the provinces and regions, with exceptional changes in energy supply (Chapters 5 and 6). Electricity will increase appreciably in use, as will renewable resources. Oil will increase in quantity terms, but will be cut back sharply as a share of total energy use. Beyond 2000, oil should achieve a sustainable level of production from Canadian resources. The changes in energy demand and supply are anything but easy. The possibility of not making the adjustments and substitutions in a satisfactory way greatly exceeds the possibility of doing so.

Although the most difficult and potentially disruptive aspects of the adjustment process are expected to occur between now and the year 2000, the processes of substitution and transition will carry on in even greater measure beyond 2000. The principal difference is that by the turn of the century the new directions will be well established. What will remain to be done will be the implementation of further, massive structural changes.

On the demand side, changed lifestyles and new designs for housing, communities, transportation systems and vehicles, and

for the commercial and industrial use of energy will permit further, substantial moderations in the rates of growth of energy use. Those modifications in demand will be reinforced by lower rates of population growth and lower economic growth.

Energy supply will rest on a mix of Canadian resources most of which are now used only in relatively small amounts or are only on the threshold of use -- oil from the oil sands, natural gas from frontier regions, much greater and different use of coal, increased nuclear power, a significant penetration into energy supplies by the renewable resources (solar, biomass, wind, tidal) and similar sources of energy (urban waste, peat, and byproduct energy). New methods of use will increase appreciably (district heating, energy storage, co-generation of heat and electricity), and energy resources will be transformed into convenient forms for use (electricity, synthetic natural gas (SNG), synthetic liquid fuels (e.g. methanol and hydrogen)). Some measure of these changes is noted in the indicative targets below.

Lifestyles can be less energy-intensive.

National Energy Program

This report deals with the magnitude of the transformation (Part II), principal strategic factors in the adjustment process (Part III) and recommendations (Part IV) which are designed to bring Canadians closer to a National Energy Program which people

all across the country can debate and in which they can participate. The report, therefore, is viewed as a prologue to action to ensure that the available lead time is used effectively to deal with long-term structural changes in Canada's energy system, in the economy and in Canadian society.

The objective of the National Energy Program is to ensure that Canadians achieve a sufficient measure of sustainable self-reliance in energy to ensure satisfactory economic performance and enhanced individual and social well-being from now through to 2025. The keystones to long-term, sustainable self-reliance in energy in Canada are: Reduce and replace -- reduce substantially the rate of growth in energy demand, especially the demand for oil; replace imported oil with Canadian energy resources.

The recommended actions of Chapter 13 deal with the National Energy Program in five main components:

- transformation of end-uses;
- transformation of supply (a consolidated supply approach);
- managing the adjustment;
- realizing the benefits; and
- ensuring results.

Principal targets

The principal indicative targets of the National Energy Program are:

- Reduce the growth rate in energy demand for the period 1978 to 2000 to one-half the 5.3 per cent historic rate; cut the growth rate in energy demand in half again for the years 2000 to 2025. This requires not just further conservation and increased efficiency in current patterns of use, but also substantial structural changes in the supply and use of energy.
- Reduce the share of oil from 46 per cent of primary energy to 30 per cent by 2000 and 25 per cent by 2025, and reduce the share of imported oil to not more than 10 to 15 per cent of that lower oil share (nor more than 400 000 barrels a day by the year 2000); reduce oil imports to negligible amounts by 2025.
- Increase Canadian oil production by about 50 per cent by 2000 and sustain that level to 2025 -- principally from oil sands and heavy oils (with any frontier or other new discoveries

worked in); this would require possibly 15 oil sands and heavy oil plants by 2000, staging one new plant every 18 months -- an extremely difficult task.

- Increase natural gas production by one-half by 2000 and sustain that production or increase it further to 2025 -- permitting a new gas wedge, based on an assured supply, to be driven into the markets of central and eastern Canada.

- Increase coal production four or five times by 2000, with further substantial increases to 2025; extend the use of coal into many new applications.

- Increase by one-half the share of electricity in total primary energy supply so that electricity is providing at least one-half of total primary energy compared with about one-third at present. This will require increased hydro, coal and nuclear generation, as well as co-generation, use of tidal, low-head hydro and other renewables and byproduct energy.

- By 2000, supply at least 5 per cent of primary energy from renewables (other than hydro) and 10 per cent by 2025. Those amounts are the equivalent of about 400 000 barrels of oil a day in 2000, and one million barrels a day by 2025. The assembly and deployment of production and marketing forces of that magnitude, by 2000, is a prodigious undertaking.

- Ensure, if possible by 2000, and from then on, that at least one-third of the energy requirements of central and eastern Canada is provided by energy resources indigenous to those regions, and that the remainder comes essentially from the energy-surplus regions of Canada (including the northern and offshore frontier regions).

- To achieve the above transformations in energy balances, energy prices in Canada be allowed to increase to world energy price equivalence at least until costs of energy production in Canada, for supplies adequate to meet long-term Canadian energy requirements, are below world price equivalence.

- Achieve price differentials among energy resources to support the requisite substitutions of indigenous energy resources in place of imported oil, and do so on a sound economic basis.

- Ensure that the energy transformations are used as the basis of new industrial, employment and international trade policies, and to support Canada's contribution to developing countries.

- Bring into place energy reports, accounts and budgets, and a system of communications to permit widespread participation by Canadians in the National Energy Program.

The above indicative targets represent direction and magnitude of change. They are, in effect, tentative flight paths along which the transformations can take place. Individually and collectively, the targets undoubtedly will be much modified to match the rapidly changing energy situation and new, perceived needs and opportunities. Flexibility and resiliency will be keystones to the long-term programs. However, the implications of shortfalls or revisions in one program or another should be thoroughly assessed within the whole. It is not enough to accept that one target cannot be achieved, or that progress is lagging. It is then essential to identify what alternative courses will be pursued, or by how much we expect to fall short of satisfactory economic and social performance.

Although the National Energy Program should be envisaged and acted upon as a long-term, comprehensive, highly integrated approach, it is not a rigidly controlled program. One basic requirement is that people in all parts of the country understand:

- what the objectives are; what the national, regional and provincial targets are;
- what the evolving situation seems to require by way of adjustments;
- what programs are being put forward by various decision-makers in all regions of Canada; and
- how public response and participation can help to ensure success.

The success of a National Energy Program requires the reconciliation of priorities in different parts of Canada; the resolution of sharp differences in jurisdictions, perceptions and approach, and the demonstration of the mutual advantages of joint, national action.

By the same token, although the National Energy Program is seen as a complex, but consistent whole, the different components can be proceeded with separately in the private sector and by governments. However, individual projects and programs can be continuously evaluated and implemented by all participants within the frame of reference of the National Energy Program as a whole.

The provinces and the national energy program

Provincial governments exercise considerable authority over energy resources, taxation, financing, rates of development and provincial energy utilities. They also regulate or greatly influence many aspects of energy use (urban and industrial development, provincial transportation systems, and so on). New

national energy balances will be expressed ultimately in terms of satisfying local and provincial needs. Thus, an examination of Canada's energy well-being and of the appropriateness of the energy balances to Canada's economic and social future must centre to a great extent on provincial priorities and the great diversity of circumstances which are to be found across Canada.

The objective of reducing the growth rate in the use of energy applies to all parts of Canada. The objective of "backing out" imported oil is especially relevant to the Atlantic provinces and Quebec, although it could also apply within a few years to Ontario as well. Three provincial or regional objectives follow if energy self-reliance is to be achieved for Canada:

- reduce our eastern exposure by avoiding any further increase in the dependency on imported oil in the Atlantic provinces and Quebec, and prevent dependency on imported oil in Ontario and the other provinces;

- reliance on imported oil in central and eastern Canada should be essentially eliminated by the year 2000; and

- provide at least one-third of the energy requirements of central and eastern Canada from sources indigenous to those regions, and the remainder from resources available from the energy-surplus regions of Canada.

It is apparent that the energy-deficit regions of central and eastern Canada can gain from a policy of national self-reliance in energy. However, the energy-surplus provinces and regions can also gain. For them, the principal gains will come from the income generated by the sale of energy resources and energy-intensive goods and services to other parts of Canada and abroad, under nationally promoted marketing programs. The energy-surplus provinces and regions can also gain from the sale of equipment, supplies, technology and services complementary to the energy, and energy-related industries. Thus, the major incentives to the energy-surplus regions are to be found in economic and social advantage. Competitive prices must be paid for the energy, and cooperation and support given to the energy, the economic and social priorities of energy-surplus provinces and regions.

Federal government initiatives are essential if satisfactory energy balances are to complement industrial, employment and regional policies. Without national coordination, the many conflicts and gaps within provincial energy programs could work to the disadvantage of all. Energy developments in frontier areas, which come mainly under federal jurisdiction, will be coordinated within the National Energy Program. Interprovincial pipelines and other transport and storage systems are another integral part of the national energy approach. Federal initiatives can also greatly contribute to the international marketing

not just of energy resources but of energy-related goods and services. Federal participation will also be evident in energy financing, based both on domestic and international sources of funds, and in other international relations.

The energy initiatives of the federal and provincial governments cannot be separated from Canada's economic and social development in which a coordinated, national approach is essential. Moreover, the whole range of activities in the private sector must work within the combined impacts of the federal and provincial frameworks. The private sector activities include major components of the energy supply industries, the energy users, financial institutions, community and manpower activities, and so on.

Thus, a National Energy Program is much more than just an "add-on" to provincial programs. A national energy program is a matter of public perception. It rests upon a recognition of a broad, national interest -- that mutually beneficial actions can be taken within a comprehensive and an expansive view of Canada's future. Provincial differences in priorities can pose a national threat unless viewed within a national perspective. Even with our best national efforts the margin for success is very slim. The hazards would be greatly increased by a fragmented approach to our energy future (Chapter 7).

Adjustment process

To set long-term indicative targets and to establish programs of action to achieve them (or some variation of them) will not advance the energy transformations very far unless considerable attention and effort are directed at the processes of change -- the levers by which change either is brought about or is impeded. The transformations are anything but smooth and automatic. One of the policy elements, and many of the programs are directed explicitly at the process of change -- the levers of action by which the adjustment takes place. These, in turn, relate to five measures of feasibility for any component of the energy program. The "feasibility criteria" can be thought of as thresholds through which every program must pass, or hurdles which the program must overcome. The feasibility criteria are:

- resource availability;
- technological feasibility;
- economic viability;
- institutional capability; and
- social acceptability.

The levers identified for specific attention in Chapters 8 to 12 of the report relate to one or another of those feasibility criteria. The levers are:

- energy prices;

- finance, ownership and control;

- technological innovation;

- environment, health and other social considerations;

- jurisdictions, institutions, regulation, administration and management;

- manpower, equipment, supplies, infrastructure; and

- information and public participation.

Each of the above strategic adjustment factors will require substantial changes in approach to serve the future energy transformations. Pricing, pricing policies and price differentials, for example, are becoming much more "administered", yet it is important that price differentials support changes in energy demand and supply toward patterns which we can have rather than those we have been accustomed to. If the real price of oil does not increase appreciably for a number of years, there will be few additional price incentives to reduce the demand for oil, or to develop other energy supplies, or new patterns of use.

Similar difficulties will arise concerning finance, ownership and control. The financial requirements will be very great in total, and they will increasingly be for different types of energy systems which are being brought into place under much different, often more risky and less financially attractive conditions. New approaches to financing, ownership and control will supplement to an important extent the traditional approaches.

None of those adjustments will be easy or certain. However, a successful transformation of energy systems requires that the adjustment factors and the "gateways of feasibility" not only be tackled individually but also in concert. Many delays can occur before an energy project (e.g. a northern gas pipeline) meets all of the feasibility criteria and can effectively bring together all of the adjustment factors. If the delays follow one another in sequence, the project could be delayed beyond the time when it is critically needed. The management process, therefore, must strive to overcome all of the potential constraints in as short a time as possible, advancing on all of them at the same time. The staging of various projects and making choices among them will depend in no small way on which projects can meet the adjustment conditions, and which combination of projects can proceed

together at any given time. For example, can we proceed at the same time with substantial urban re-design, new transportation systems, widespread renewable resource projects and large-scale oil sands and nuclear programs? Even if we can so proceed, are the results of the various activities compatible and balanced?

"Nowhere in the Occident is there the will and the vision to make the energy crisis the opening act in a drama of renewal and rebirth ...The danger is that we shall not get off the treadmill...It is this lingering, debilitating crisis that we have to fear most."

-Eric Hoffer, In Our Time, Harper & Row, New York, 1976.

Energy and economic and social progress

The energy programs underpin the future economic and social well-being of Canadians. Although the transformations are great and fundamental, they can proceed in an orderly way from beginnings already underway. They do not require a completely different economy and society. However, the transformation of the energy system can provide a major economic and social dynamic right across the country. Three factors of the economic and social opportunities are especially noteworthy. These are:

- the manpower, equipment and supply requirements to transform the energy system offer a wide range of industrial, employment and income opportunities;

- exploitation of the new energy capabilities will support other industrial and employment opportunities; and

- new technologies, new skills, new systems and management arrangements can be used to great advantage within Canada and to our international advantage.

These broader concerns are considered within the scope of a National Energy Program. They establish much of the framework within which the objectives and the recommended actions for that program must be set.

Recommended actions

Chapter 13 outlines 28 recommended programs, all or some of which can be immediately undertaken, building upon initiatives which are now being taken. The 28 programs relate to 5 principal policy elements. These are:

- the transformation of energy end-uses (5 programs);
- achieve a consolidated energy supply position (8 programs);
- facilitate the process of adjustment (7 programs);
- realize the economic and social opportunities (4 programs); and
- provide for public information and participation (4 programs).

Possibly the most urgent need, and one for which additional action can readily be undertaken, is public information and participation. The information and assessments which are required, all across Canada, to support public participation will be essential supportive inputs for all of the other programs and policy elements.

The large city will be a principal focus for energy transformations.

Market economy and international dependency

Two broad considerations might be noted in respect of energy adjustments and economic processes. These are:

- will the long-term energy adjustments occur simply in response to normal market incentives? (the "market economy" approach); and

- why should Canada emphasize energy self-reliance when countries such as Japan have relied, and will continue to rely, almost entirely on imported energy? (the "international dependency" approach).

Long-term energy adjustments will take place under the impetus of market forces, particularly much higher energy prices. In this assessment, changing energy prices are seen as the principal factor in bringing about reductions in energy demand, increases in energy supply, and the replacement of oil, in substantial part, by other energy resources (interfuel substitution). Some characteristics of the complex pricing arrangements are outlined in Chapter 9. Perverse price signals are likely to precede, for a time, the higher energy prices which will be a clear indication that adjustments are necessary. As a result, the timing of the adjustment process will be made more difficult. There will not simply be easy and fairly automatic adjustments as a result of changing energy prices. It is also important that price differentials underpin the energy substitutions which are necessary for self-reliance and which permit satisfactory economic performance and social well-being. Because prices are largely "administered", market forces will need support from government pricing policies and from other incentives which are clearly consistent with the long-term energy objectives which are generally supported by the Canadian people.

A number of industrial countries, of which Japan is one, are heavily dependent on external strategic resources, including energy. Why, then, should Canada emphasize energy self-reliance? One reason is that we have an opportunity to achieve self-reliance. Most other countries would prefer to do so, but cannot. Countries such as Japan have, over a long period of time, built their international trading advantages and their domestic economies around other strengths. Even while striving to achieve energy self-reliance, Canada, like the energy-deficient countries, will be seeking to conserve energy, to use it much more efficiently and to make major structural adjustments to the economy. At the same time, Canada can expect to be in a more favourable energy position compared with many other industrial and developing countries. By seeking complementary economic relations with those countries, Canada can take advantage of its comparative advantage in energy and its energy-related technological innovations to improve its international trade relations.

A few perceptions underlying the assessment

World oil price

Possibly before 1990, world oil production will no longer keep pace with the demands for which oil is the preferred energy resource. The result will be substantial, possibly highly disruptive, increases in the price of oil and, quite possibly, severe disruptions to supply. For purposes of this assessment, the world price of oil is expected to double (in real terms) by the year 2000. At some point, probably before the year 2000, the price of oil will cease to be the common energy reference price. Other energy prices will no longer be substantially determined by the world oil price. In Canada, the price of the kilowatt-hour of electricity, based mainly on nuclear power, might set the competitive pricing standard for energy. Many other energy resources and byproduct uses of energy will be price competitive with world oil.

The assessment that the real price of world oil (beyond general price increases) will double by the year 2000 is both critical to the whole analysis and the subject of substantial controversy. If one takes the more comforting view, supported by the current, short-term situation, that the real price of oil need not increase appreciably over the next 20 years, it is also necessary to assume that oil supplies will meet fully the preferred demands for oil over that period. If that were so, there would be little incentive to substitute other forms of energy for oil, and the incentives for greater conservation and increased efficiency, in all countries, would be greatly blunted. As a result, we might expect the world to rely on oil for about the same relative share of total energy (nearly one-half) that now exists. However, the physical quantities demanded would be more than twice what they now are (unless world economic performance was especially unsatisfactory). Even if that situation might conceivably exist until the year 2000 (surely most improbable), how long beyond 2000 could world demand for oil continue to increase unimpeded before supplies became wholly inadequate and the real price of oil again rose sharply?

This Futures report concludes that substantial increases in the real price of world oil are most likely to occur well before the year 2000, probably not later than 1985. However, this assessment is less concerned with trying to pin-point the timing of the increases in real oil prices than with emphasizing the implications of what seems to be the inevitable price increases and the potentially very disruptive future world oil situation.

Freedom of choice

The principal objective of the report is to ensure that energy is available to Canadians in sufficient quantity and of adequate

types to maintain satisfactory economic performance and to serve the reasonable aspirations of Canadians for individual and social well-being. Basic to that requirement is the objective of retaining and of increasing freedom of choice for individual Canadians to pursue preferred lifestyles under the discipline of greater energy constraints. Only in extreme cases would central control or allocation of energy supplies be resorted to. Although government participation in energy matters will increase appreciably, market forces and the initiatives and energies of private individuals will be relied upon in large part to alter patterns of demand, bring forward the requisite energy resources, and allocate them according to the preferences of Canadians. The job to be done, however, is so difficult that the highest degree of advance planning and program coordination, involving all levels of government, industry and the public are essential.

Role of the government

Although market forces and widely dispersed, individual and corporate decisions are expected to be the mainspring of the energy support system, a much expanded role for imaginative and forceful initiatives by all levels of government will be required. It is in the conjunction of a substantially different array of government actions and of those by industry and the public that the possibility of a satisfactory energy future for Canadians will be determined. Government leadership is essential to ensure the initiation of the necessary activities across Canada and their coordination in ways which implement the views of Canadians around the national interest.

Political continuity

No major disruptions are assumed to occur in Canada or abroad that prevent an orderly process of policy development and implementation. The assumption calls for the political continuity and geographical entity of Canada as it now exists. Indeed, the energy situation offers opportunities to forge strong new links across the country. The pursuit of satisfactory energy and economic futures can be a powerful force supporting national unity and national identification.

Other assumptions

Throughout the report many assumptions are implicit or are mentioned explicitly. In a report of this nature, the conclusions spring largely from the assumptions which go into it. As noted above, the critical perception, based on a comprehensive study, is that the world price of oil will increase sufficiently to justify a great variety of energy programs in Canada. These, for the most part, will be directed toward conservation of energy, increased efficiency in its use, changes in lifestyles and patterns of energy use, and the bringing forward of a much

different array of energy supplies from the variety of available resources. The second perception is that new dimensions of organization, effort and management are essential if a satisfactory future for Canadians is to be achieved under energy conditions so vastly different from what we have experienced in the past. We must plan to use the energy which we can have in 25 years' time, not the energy we have been accustomed to use in the past.

Single view of the energy future

To assess a support system as vital to society as energy, over a span of 50 years, requires that many widely different views of the future be considered, but only one combination of developments is presented in this report. Why were not wide-ranging alternative futures presented to give an impression of how uncertain the future is, and what span of possibilities exists?

A wide range of futures was considered, but it became increasingly evident that the essential problems remain in different combinations. No variations were identified which represented a significantly easier future, particularly over the next 25 years. Over the longer term, the range of variations increases, but they all call for changes so fundamental that a start should be made now even for those programs whose greatest impact will be felt after the year 2000. The substantially different patterns of energy supply and use which will be available at that time will be associated with significant changes in economic opportunity and in lifestyles, but they do not require a complete upheaval in our way of life. Many of the major transformations will be very much under the influence of, or to a substantial degree determined by, the changing energy situation.

One fundamentally different perception of the future required explicit examination. It can be presented in two forms. First, that the energy adjustments will not really be very great -- that world supplies of oil, gas and other energy resources will come forward, as in the past, more or less as required; that demand reductions, largely induced by higher prices, will be substantial and that, hence, no unusually great, or difficult transformations will be needed. The principal focus of that process of easy adjustment typically is the next 5 to 15 years. The second and longer term variation of the "easy adjustment" perception foresees great transformations taking place, but in fairly easy stages over a longer period of time. As a result, Canadians and other people in the world would be living in a profoundly different society. The large industrial complexes and large urban centres would diminish greatly in importance in favour of small communities mainly self-reliant in energy. Individual energy demands would be greatly reduced in a "new society". Energy would be supplied in large part from solar power, biomass, wind, tidal and other renewable forms.

This "Energy Futures" report incorporates elements of both these perceptions -- we need not face a panic energy situation in the next few years and, over the longer term, the renewable resources, conservation, slower, but satisfactory economic growth, more effective handling of environmental concerns, of risks and uncertainty, and the much more efficient use of energy are essential components of this long-term adjustment process. However, this report differs in two important respects from the "easy adjustment" perception of both the short and the long-term. First, the adjustment and transformation process will be anything but easy or automatic. In the short-term (to 1985 or 1990), in the intermediate term (to 2000), and in the long-term (to 2025), very substantial stresses and strains can be expected to develop in the Canadian energy situation and to a greater extent in the world situation. New incentives and an array of innovative approaches to adjustment will be essential to offset those stresses, avoid disruptions and to carry through satisfactory transitions.

Secondly, the successful handling of one of history's greatest transformations will require radically different approaches in institutions, management and public participation in Canada and throughout the world. Even if the costs of taking action were considered to be great, the costs of not taking action would be much greater. In one important sense, however, efforts to provide satisfactory energy adjustments and economic and social transformations can be viewed as essentially costless. The successful adjustments, once clearly perceived, can proceed systematically and progressively through time. To plan and implement the adjustments within perceptions of the longer term, "third dimension" of time will add negligible further costs. No matter how many variations or alternatives are considered, they all point to the same conclusion: to evolve an energy system which will enable us to achieve some improvement, or at least no serious deterioration, in individual and social well-being will be the most demanding task undertaken by Canadians in peace time. The essential thing is to put together the National Energy Program with imagination, skill and vigour. The adjustments will not all be those outlined in this report, but the variations likely will present the same order of difficulties and opportunities. There are no easy solutions. Institutional and management systems will need considerable restructuring around coordinated programs which serve clear objectives. Reassessments of the energy situation, the targets and programs need to be continually made on a nation-wide basis. The National Energy Program requires full public involvement.

The single view of the future which is presented in this report is seen simply as the prologue to a national dialogue which will marshall the diverse initiatives across Canada into a comprehensive, national drive to achieve satisfactory energy futures for Canadians.

Source material, references, analytical techniques

The nature of the data assembly and information sourcing makes specific reference throughout the report difficult and cumbersome. Appendix 3 outlines briefly some procedures which were used, including the establishment of 10 task forces, a number of which produced background assessment papers. Much of the basic analytical approach and the background data are included in the work of the task forces and the assessment papers. Further extensive consultations were carried out and much additional reference material was used. However, the emphasis of the report is not on rigorous data manipulation or on precision of estimates. The emphasis is on orders of magnitude and illustrative positions which, while as accurately presented as possible, are designed to demonstrate a perception and a need. Differences in data or analytical interpretation would result in any number of differences in detail. Investigation of many of those differences, however, revealed that while they alter a number of the relationships they do not fundamentally alter the central perception or the main conclusions of the report -- the magnitude of the transformations is extraordinarily great and difficult no matter how the particular variations are brought together.

The data, the analyses and the conclusions, based in part on so many sources, support the recommendations in this report that the establishment of a comprehensive, systematic data base and energy accounts be given a high priority. Supporting analytical systems, wherever they exist across Canada, would then have identifiable linkages.

"...any long-term Canadian energy policy should be evaluated, in large part, against the degree of flexibility it preserves."

-Delphic Consulting Ltd., "Social and Economic Implications of Alternative Energy Futures: A Planner's View", p.67.

Part II

MAGNITUDES OF CHANGE

2 WORLD ENERGY FUTURES

Chapter guide

- *The world could face an extremely serious energy situation within 10 years, serious enough to cause economic distress and social unrest.*

- *A doubling of the world's population by 2025, and the growing proportion of population and economic activity concentrated in the developing countries means that western industrial countries will not dominate world consumption of energy, or world wealth, as they do now.*

- *By 2025, coal and nuclear power might provide nearly 70 per cent of world energy, with oil, natural gas, hydro power and renewables sharing the balance.*

- *By the year 2000, international trade in oil and natural gas (LNG) will have peaked and begun to decline.*

- *Oil prices (in real terms) can be expected to double before the year 2000, and countries will be forced to reduce their dependency on imported oil for reasons of unavailability, not just price.*

- *Each country and region will seek to establish a high degree of energy self-reliance, based on renewable resources and, in many instances, nuclear power; even so, world trade in energy products (in thermal equivalence) might double by 2000 and almost quadruple by 2025. This could pose serious difficulties, especially in energy transportation.*

- *Coal might replace oil, in volume terms, in world energy trade by about 2000. Hence, regional patterns of energy trade will shift toward coal exporting countries. The Soviet Union and the United States have the largest known coal reserves.*

- *Nuclear fuels likely will be a significant part of trade in value terms, although the amount of inter-regional trade in nuclear fuels is not expected to be exceptionally great, especially if fast-breeders or thorium-fuelled reactors come into commercial use by the turn of the century.*

Chapter 2. WORLD ENERGY FUTURES[1]

At present, world oil production is readily meeting current demand, and no inability to supply markets seems evident over the next few years. However, the world could face an extremely serious energy situation within the next 10 years. Beyond that time, a deteriorating world energy future could cause serious distress among world societies. Much higher energy prices and energy shortages, spread unevenly around the world, might well occur. At present, partly in response to the sharp increases in world oil prices, the world's economic performance has fallen below a satisfactory level. With improvement in this performance, shortages of energy could develop rapidly. The nations of the world can either wait to make major adjustments under crisis conditions, almost certainly with energy allocation and controls, or they can begin now to plan and to implement major adjustments by conservation measures and by re-structuring energy demand and supply to achieve a less disruptive transition.

The energy needs of the world will derive from three principal factors:

- the growth and distribution of the world's population;

- the growth and changing structure of the wealth and economic systems of both the developed and developing worlds; and

- the improvement in efficiency in the use of energy to meet the growing requirements.

The capacity to achieve viable world energy balances, including regional world energy balances, will depend crucially upon the development of new supply capabilities from all energy sources within each region and upon the effectiveness of world trade in meeting the substantial changes in world energy demand.

The ramifications for Canada of the world energy outlook are so great that "Canada and World Energy" (A World Energy Watch) is identified as a <u>Strategic Issue Area</u>[2] for much more detailed assessment. Such an assessment would extend to international

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1 The data for this Chapter are based, for the most part, on "World Energy Supply and Demand Analysis", van Meurs and Associates Limited, Ottawa, 1977 -- a study for which Energy, Mines and Resources Canada (the Energy Review Group) was a sponsor.

2 See Appendix 3 concerning <u>Strategic Issue Areas</u>.

financing, industrial, resource and foreign policy implications, and to a broad range of other energy-related international relations.

Population trends

No long-term assessment of future energy balances can ignore the possible trends in world population. Estimates of the future population of the world are depicted, by region, in Figure 2-1.[1]

The world population is forecast to more than double over the coming 50 years. This reflects, in the main, a growth rate about twice as high in the developing countries as in the present industrial world. It can be seen that the population of OECD countries and Eastern Europe is projected to increase slowly, with the result that the population of developing countries is expected to make up two-thirds of the world total by 2025, compared with about one-half at the present time. The developing countries have been divided between those with a high potential for economic growth and those with a low potential for economic growth. (A growth rate of 4 per cent was used as a cut-off.) High growth areas are the Middle East (including Iran), North Africa, Latin America, Nigeria, South Africa and East and Southeast Asia. Low-growth areas are Middle South Asia (mainly India) and "other Africa". The areas with low economic growth potential will have a population growth more rapid than that for the world as a whole, and by 2025 will approach 40 per cent of the world total compared with less than 30 per cent at present.

The forecasts of world population growth are subject, of course, to significant margins of error because the quality of the data base in some highly populated areas of the world is poor, and future growth rates of population are, to say the least, uncertain. However, even if a somewhat lower rate of population growth is assumed, no significant reduction in energy demand likely would result. In some countries, a lower rate of population growth might well result in an increase in the use of energy if it meant higher wealth per capita.

Table 2-1 presents the regional differences in population in more detail. For example, the Middle East and North Africa region, which now has a population of about two-thirds that of North America, will be 13 per cent larger by the year 2000, and nearly 90 per cent larger by 2025. This region will command great financial resources, shows a keen interest in industrial

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1 World Population Forecast, 1975-2025, Dr. D. Ivan Pool, Appendix A to the van Meurs study, ibid.

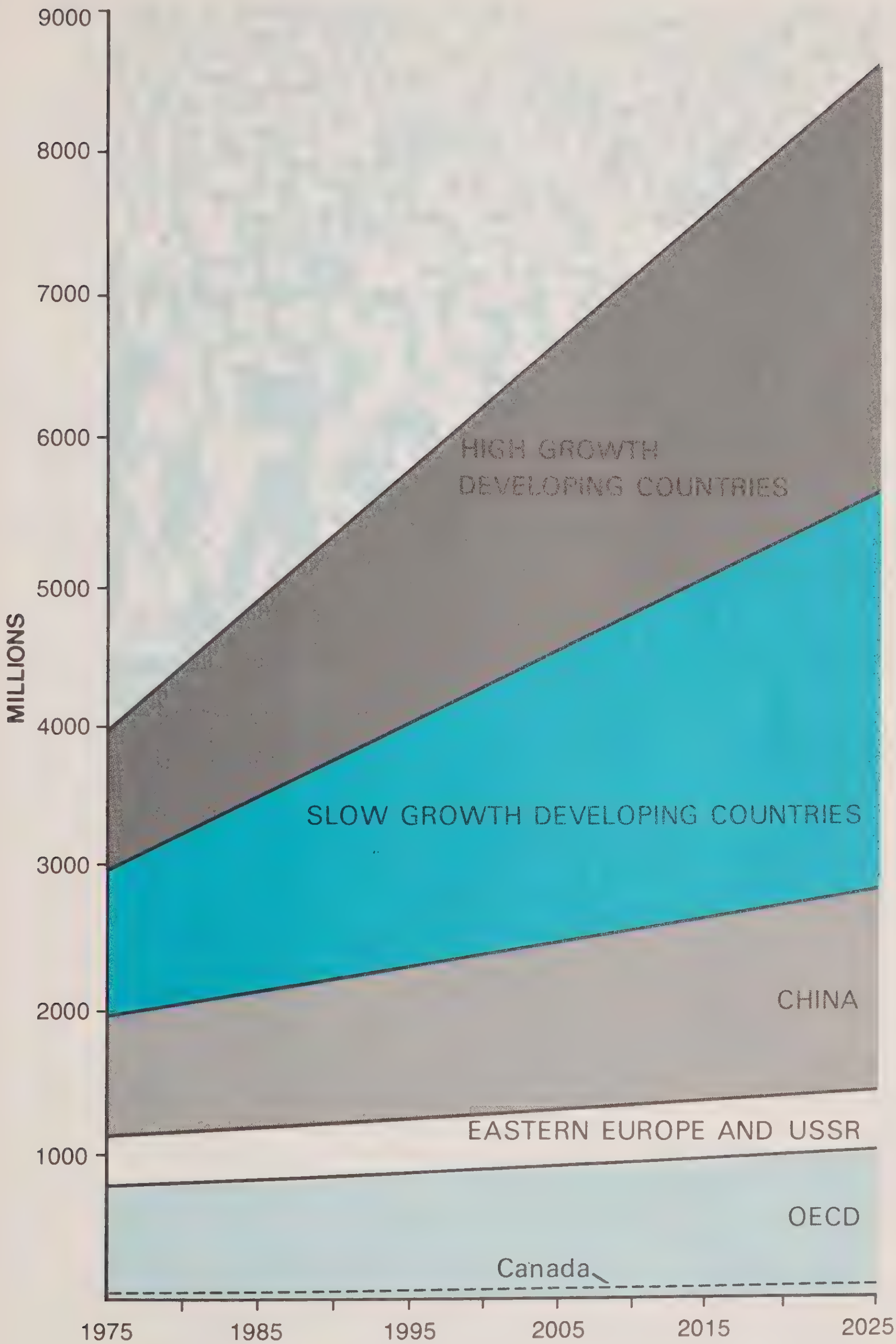

Figure 2-1. World population by region, 1975-2025.

development, and has first call on much of the world's supply of oil and natural gas.

Rapid rates of population growth are also evident in Latin America and in much of Asia. Latin America and the Caribbean, which in 1975 had a population somewhat smaller than that of Western Europe, will be nearly 50 per cent larger in 2000 and 130 per cent larger by 2025. However, much of the rapid growth in the world's population occurs in areas with limited potential for economic growth. The Indian sub-continent is projected to have a population of over 2 billion people by 2025 but its relatively low rate of economic growth is likely to curtail its command of world energy.

TABLE 2-1
World Population by Region

	1975		2000		2025	
	million	per cent	million	per cent	million	per cent
Western Europe, North America and Japan	716	18	836	14	892	10
Eastern Europe and USSR	361	9	435	7	465	5
Middle East and North Africa	163	4	325	5	585	7
Central and South America and the Caribbean	325	8	615	10	1 010	11
Indian sub-continent	805	20	1 434	23	2 210	25
East and Southeast Asia (excluding Japan)	1 246	31	1 854	30	2 336	27
Africa, South of Sahara	315	8	630	10	1 165	13
Other and adjustments	69	2	71	1	137	2
World	4 000	100	6 200	100	8 800	100

The movement of population into urban centres could have an important influence on energy consumption. In 1970, about 37 per cent of the world's population lived in urban centres; by 2025, more than 50 per cent is likely to do so. The percentage of the population of selected regions which was urban in 1970 and is

expected to be in 2000 is set out in Figure 2-2. The growth of large centres (100 000 plus) is expected to be particularly pronounced in the developing nations. In 1970, 6 of the 10 largest agglomerations were in Europe or North America. By 2000, 8 of the 10 largest urban centres will be located outside of Europe and North America. By the year 2000, Mexico City might have a larger population than all of Canada, and the Tokyo-Yokohama metropolitan complex and Sao Paulo might be not much smaller in population than Canada at that time.

Economic growth and structural change

The dramatic growth and shifts in the world's population will have profound effects on incomes over the next half century. Economic growth typically has had a greater effect on increases in energy consumption than a comparable growth in population. The rate of future economic growth is expected to be lower than that of the last two decades. The growth will be distributed unequally around the world. Economic growth in the world economy is expected to average about 3.5 per cent annually from 1977 to 2000, and about 2.8 per cent from 2000 to 2025. The world rate of economic growth beyond 2000 is expected to be higher than that anticipated for Canada, principally because of the more rapid growth in some of the developing countries. World economic growth can be expected to put severe strains on energy supplies and on the logistics of international energy trade. However, any further reduction in growth rates might reflect inadequate energy supplies or inadequate trading capability and, hence, be a sign of unsatisfactory performance.

The Middle East and North Africa are expected to experience the most rapid rates of economic growth. Western Europe, North and South America, Eastern Europe and the USSR, Southeast Asia and China are all expected to have a fairly strong rate of economic growth, sufficient to allow for some improvement in the income of their people. If these patterns of growth materialize, by 2025 the countries of the OECD, which now produce two-thirds of the world's gross domestic product, would account for less than half. (See Table 2-2.) The Middle East and North Africa would nearly quadruple their share of total world output. Eastern Europe and the USSR would maintain a constant share, whereas China and other developing countries might nearly double their relative contribution to world economic output. The moderate economic growth of the Indian sub-continent and of Africa south of the Sahara will be overwhelmed by their population growth so that their people can expect little or no improvement in income per capita. Whereas the average Canadian GDP might almost triple (in real terms), from about $5 500 in 1973 to nearly $17 000 per capita, that of India might rise only from $129 to $190.

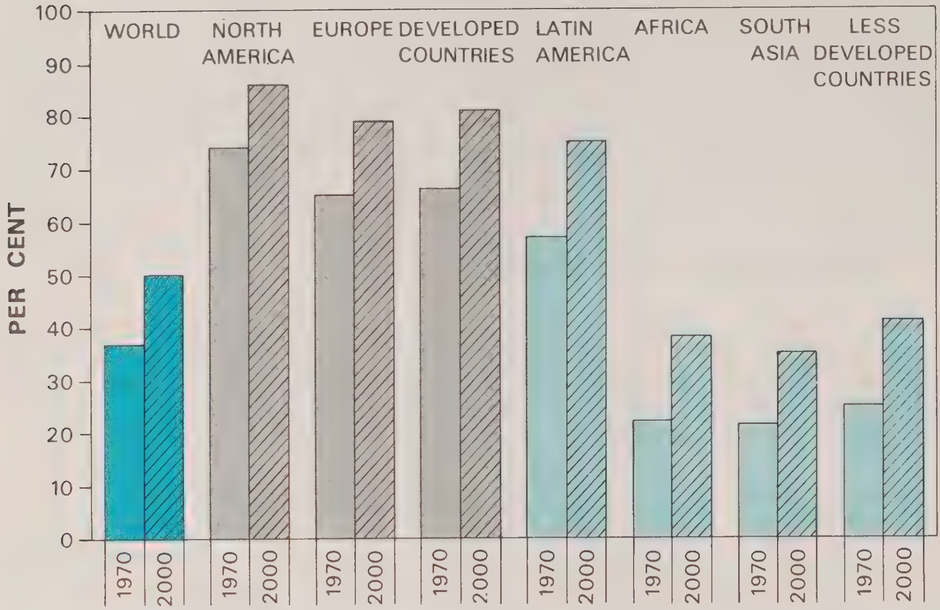

Figure 2-2. Percentage of world population[1] in urban centres by selected regions, 1970 and 2000.

Significant structural changes in the economies of the different regions of the world will go hand in hand with changes in rates of economic growth. The mature economies of the developed countries are already undergoing energy-induced structural changes associated with the five-fold increase in the price of oil during the 1970s. Over the medium and longer term, lower rates of increase in population and other factors will tend to slow the aggregate economic growth of these regions compared with that experienced over the last two decades.

To achieve satisfactory, even if slower, rates of economic growth in the future will require further improvements in productivity. In the past, higher degrees of productivity were attained by putting more machinery and equipment at people's disposal. The production and use of this capital resulted in a more energy-intensive economic structure. In the face of increases in the cost of energy, however, a countervailing influence will come into play -- new machines and equipment will

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1 Based on data from Vallin (1976, Tableau 7), as presented by van Meurs, ibid.

be designed to use energy with increasing efficiency. The ability of the developed countries to substitute advanced, energy-conserving technology will be an important factor in lowering the energy intensity of these economies.

Another significant trend in the OECD countries is the rapid growth of the service sector. The energy intensity of this sector is not very well understood. In the future, much more attention will have to be paid to the energy use and efficiency in service industries (e.g. amount of floor space in offices and hospitals, and the energy consumption of commercial and public-service buildings).

Eastern Europe and the USSR are experiencing similar structural changes to those in the OECD countries. The USSR is insulated to a certain extent from the influences of world energy prices because of its vast, indigenous energy supplies. The countries of the Middle East and North Africa are transforming their economies to cope with their dramatic population changes and to take full advantage of their capacity to generate wealth. The oil and gas resources of that region are being directed in part towards industrial projects, such as large petrochemical works and fertilizer plants, whose products will enter world markets. The possible doubling of China's share of total world economic output will be fuelled from its own energy resources, but will thus limit the export of energy resources from China. Many countries in Latin Amercia and Asia are at a take-off stage for rapid industrial development which will generate heavy energy demands. In many instances, their indigenous energy resources have not been well evaluated.

Urbanization usually is associated with industrial development and with a growth in transportation facilities and other energy-intensive infrastructures. In addition, the mechanization of rural economies can also sharply increase energy demands.

In the industrialized areas of the world, the ratio of the increase in energy to the increase in gross domestic product is expected to be lower than in the past, possibly about 0.6 to 0.8 per cent from now to 2000, compared with an almost one-to-one increase in the last 25 years. These improvements in energy efficiency will be far from easy. The lower relative energy use will result from the higher relative price of energy, the increasingly efficient use of energy, and the inability of the industrialized countries to consume large increases in energy (a kind of saturation effect). However, the improvements in energy efficiency in the industrialized countries will be more than offset, in terms of total world energy consumption, by the increasing demands of the developing world.

An important consideration in the oil-poor, developing countries is to establish patterns of energy demand which can

TABLE 2-2

Per Cent Share of Different Areas in Total Gross Domestic Product

	1973	1985	2000 (per cent)	2025
OECD	65	61	57	48
Eastern Europe and USSR	19	19	19	18
Middle East and North Africa	2	4	5	8
China	4	5	6	8
Other developing countries	10	11	13	18
Total	100	100	100	100

take advantage of heretofore undeveloped, indigenous resources. This approach, at first, might seem to be an attempt to deny developing countries the advantages of oil which has powered so much of the industrial world's economic wealth. On the contrary, the development of indigenous energy would prevent, in 10 or 20 years' time, a very difficult reverse adjustment. If developing countries now go heavily on to an oil-based economy (with all its attendant balance of payments problems), they later will have to adjust away from oil just as will the industrial world. To some considerable extent, the developing countries, given long-term development plans and some technological assistance, could make the adjustment to indigenous resources directly and thus avoid the problem which will confront the industrial world of breaking away from so dominant a reliance on oil. Canada can make a valuable contribution to developing countries by assisting them with the deployment of technologies which, in many instances, Canada will be developing for its own use.

World energy use

Small variations in the basic assumptions about economic growth and the sensitivity of net energy demand to increases in income can cause wide variations in estimates of energy demand by the year 2025, and in the cumulative energy requirements from now until the year 2000 or 2025. For purposes of this assessment, an annual growth rate of 3.5 per cent in primary energy consumption can be taken as representative. At that rate of growth, the world's primary energy use would increase from about 130 million barrels of oil equivalent per day (MMboepd) in 1975 to more than 300 MMboepd in 2000. If the rate of growth then averaged only 3 per cent a year to 2025, energy use in that year would be well over 600 MMboepd, approaching five times current use. Those are tremendous additional quantities of energy to supply on an annual basis and on a cumulative basis from now to 2025.

The difficulties of the world's oil supply are also illustrated by the increases in energy consumption. If one-half of the total continued to be oil, the world would require about 150 million barrels of oil per day by the year 2000, about three times current demand. If the OECD countries continued to use one-half of the total world oil, their oil requirements would increase to about 75 MMbopd compared with less than 50 MMbopd in 1975. Under those circumstances, as early as the year 2000, the OECD requirements alone would approximately equal total world anticipated oil production, in spite of increasing demands from other countries. The potential imbalance, and hence the inability of world oil production to meet the increasing demands, would get rapidly worse beyond 2000. Very drastic adjustment efforts are, therefore, called for. The international economic, social and political implications of the changing shares of net energy use are immense, but lay outside the scope of this report.

Nor is the situation in total made much easier by the anticipated changes in the proportions of oil used by the various regions. By this assessment, the OECD share of total world energy consumption would decline markedly between 1973 and 2025 -- from approximately 60 per cent to just over one-third. Eastern Europe and the USSR would maintain their share, at about one-fifth the total, while the share of the Middle East would quadruple, and that of the developing world as a whole would double by 2025. These changing energy shares are illustrated in Figure 2-3 in comparison with the changes in population and in gross domestic product which were referred to earlier. The changing shares of net energy use (final demand) are presented in Table 2-3.

TABLE 2-3

Regional Shares of Total World Net Energy Use

	1973	1985	2000	2025
		(per cent)		
OECD	61	54	47	37
Eastern Europe and USSR	21	23	23	20
Middle East, N. Africa and Iran	2	3	5	8
China	7	9	11	14
Other developing countries	9	11	14	21
Total	100	100	100	100

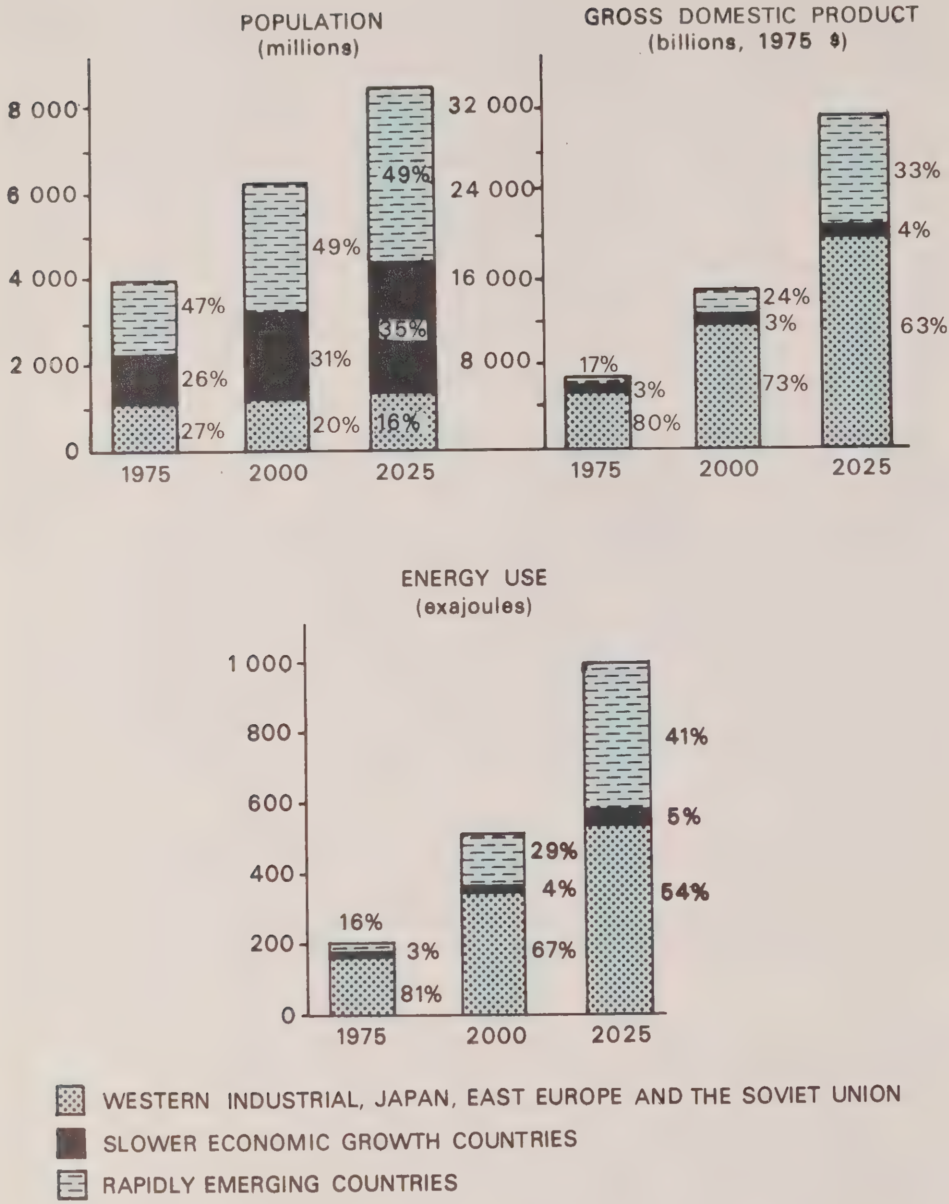


Figure 2-3. World population, gross domestic product and energy use.

World energy production

The dramatic changes in the share of the various resources in the world's energy production are illustrated in Figure 2-4. The shares of oil and natural gas decline appreciably. Increases are recorded for coal, "nuclear and hydro power" (mostly nuclear), "other resources" (mostly renewables and byproduct forms of energy).

Conventional oil

World supplies (production) and remaining reserves of conventional oil are depicted in Figure 2-5. World oil production might increase from about 57 million barrels per day in 1976 to about 80 million barrels per day around 1990, a rate of increase of about 2.5 per cent annually. Beyond 1990, oil production would decline to about 54 million barrels per day by 2025. Countries in the Persian Gulf area might well restrict their rate of production for resource conservation and economic purposes. By this estimate, proved reserves will increase to the year 1990, or thereabouts, then decline. The decline in world production probably will follow the drop-off in reserves by a few years.

Heavy oils, oil sands and oil shales

After 1985, production from heavy oils, oil sands and oil shales is expected to increase gradually to a level of 6 million barrels per day by 2000, and 21 million barrels daily by 2025. Oil from these sources would reduce but not redress the decline in conventional world oil supplies. However, these sources of oil, drawing from large potential reserves, could sustain a basic oil supply for many years beyond 2025.

Natural gas

World natural gas production can expand rapidly without the discovery of more reserves. Remaining world proven reserves of natural gas are estimated at 2.3 quadrillion cubic feet. Currently, one cubic foot of gas is produced for every 43.4 cubic feet of gas reserves. Very large reserves are located in North Africa and the Middle East, most of which are not now being tapped. Large volumes of natural gas will move into international world trade between 1985 and 2000. Total world gas production is expected to more than double between 1973 and 2000, then drop slightly to 2025. In volume terms, natural gas production is expected to be the equivalent of about 50 million barrels of oil per day in 2000, and 43 MMboepd in 2025, compared with about 23 MMboepd in 1973. World annual production of natural gas liquids is expected to double from the present volume of nearly 4 million barrels per day to more than 8 million by 2000, then remain fairly level through to 2025.

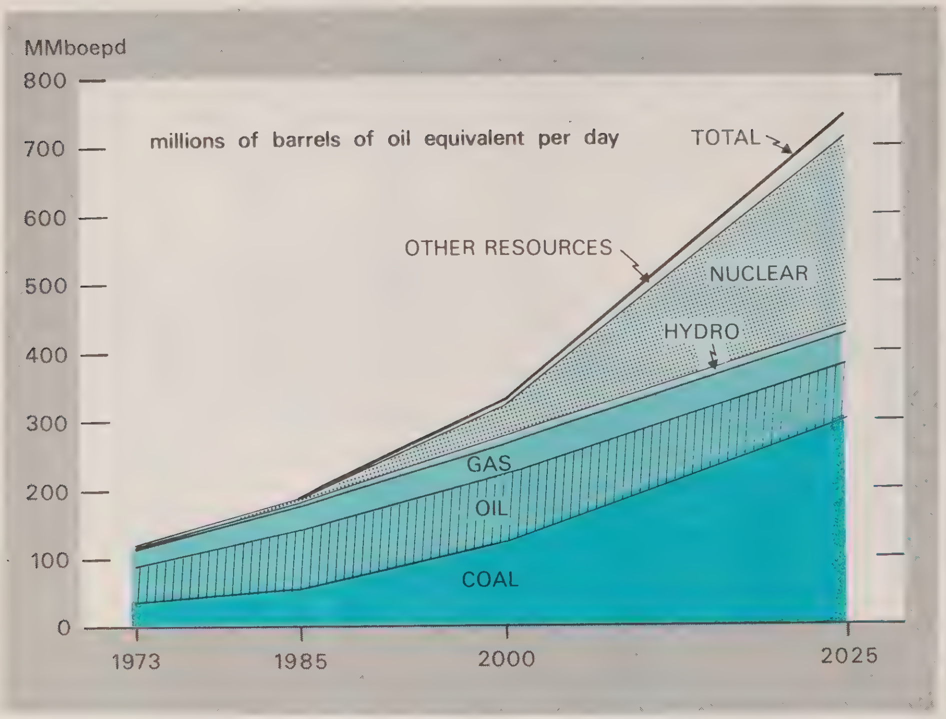


Figure 2-4. Potential world primary energy production.

Coal and lignite

Most of the world's known recoverable coal reserves are located in the United States (37 per cent); USSR and Eastern Europe (26 per cent); China (15 per cent) and Western Europe (10 per cent). Australia (4 per cent), South Africa (2 per cent) and Canada (1 per cent) have significant recoverable coal reserves. Only 5 per cent of known reserves are in the developing world, excluding China.

World production of coal in 1973 was rated equivalent to 34.2 million barrels of oil per day. World production might rise to 126 MMboepd by 2000 and as high as 300 MMboepd by 2025. This would represent an average annual growth rate to 2025 of 4.3 per cent. However, whether coal can be produced, delivered and used in such vastly increased quantities is not known. The actual production in many areas will be severely constrained by the local resource base, the distance of coal resources from existing markets, the availability of preferred, alternative resources, and the high cost of production in some areas. Environmental constraints might severely limit the production, transportation

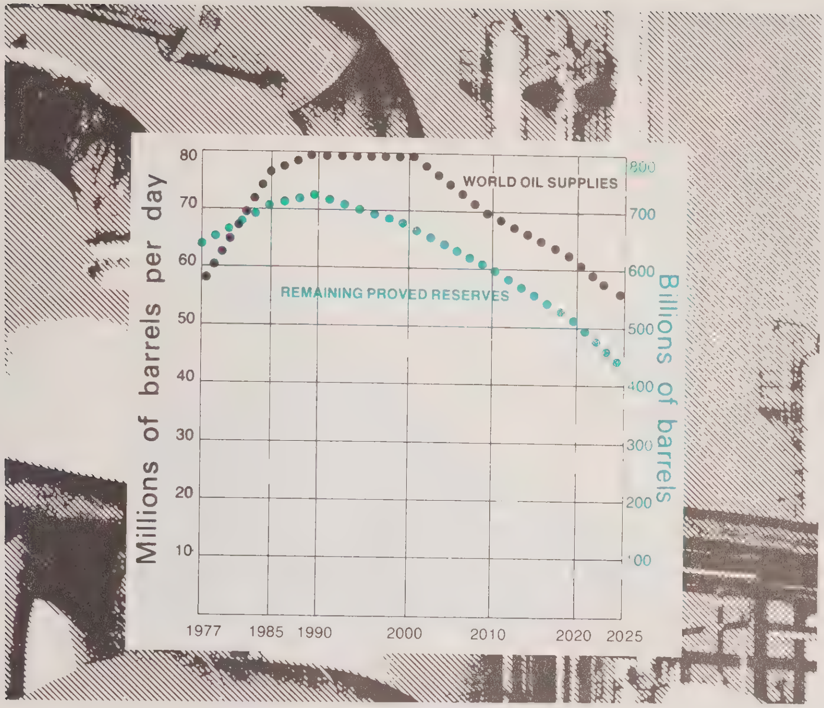


Figure 2-5. World supply and reserves of conventional oil, 1977-2025.

and use of coal. For the above reasons, the levels of production depicted in Figure 2-6 should probably be regarded as maximum potential, particularly beyond 15 billion tons per year. Coal gasification and coal liquefaction might contribute an additional 6 and 12 MMboepd, respectively, by the year 2025.

Hydro power

Latin America, Africa and Asia have large untapped hydro resources. More hydro power development could take place in the USA, Canada and Eastern Europe and the USSR. It is expected that these resources will be developed rapidly until the year 2000, and that thereafter the growth rate will slow. World hydro power production is expected to increase from 2.2 MMboepd in 1973 to 10.4 by 2025 (or from 1.3 x 10^{12} kWh to 6.0 x 10^{12} kWh). By 2025, most of the world's hydro power resources will have been developed, with the exception of some of the large resources in Africa.

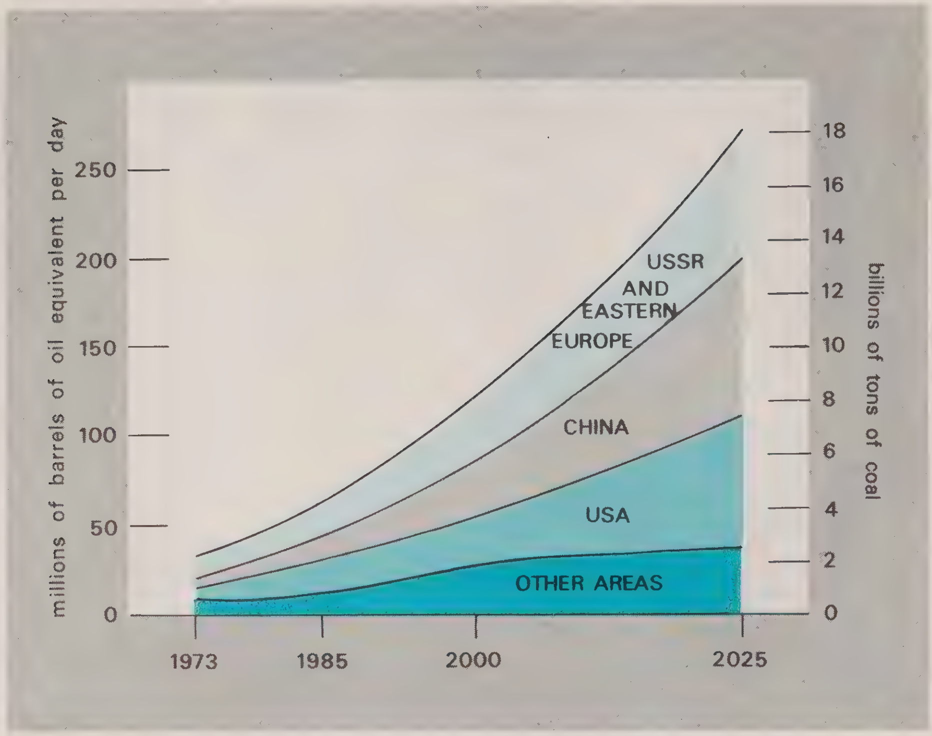


Figure 2-6. Potential world coal production, 1973-2025.

Nuclear power

Nuclear power is expected to make a very important contribution to future energy supplies. It is estimated that by 2025 up to 60 per cent of all electricity might be generated by nuclear power. If this were to occur, nuclear energy and hydro power would supply virtually all of the base load electric power. Initially, nuclear energy will be used in the OECD countries, Eastern Europe and the USSR. By 1985, nuclear power could begin to make important contributions in developing countries such as Brazil, Mexico, India, Iran and South Korea. By 2025, half of the nuclear power might be generated outside the OECD countries. This points to problems related to the proliferation of nuclear materials and to waste management. Nuclear power (on an input basis) might grow from one MMboepd in 1973 to 11 by 1985, to more than 45 MMboepd by 2000, and to 280 MMboepd by 2025.

It is extremely difficult to move from these estimates of nuclear power to the amount of uranium which will be required as

fuel. However, using assumptions similar to a recent OECD uranium study[1], uranium demand might be of the order of 210 000 tons per year by 2000, compared with about 20,000 tons in 1975. By 2000, approximately 2.5 million tons of uranium will have been used in the production of electricity. Beyond the year 2000, allowance would also have to be made for alternative fuels and greater use of breeder reactors or other advanced nuclear systems. At the same time, however, there may be increased demand for nuclear power beyond the requirements for electrical generators, particularly for various thermal applications.

Other energy sources

Primary energy production from a wide variety of other energy sources could contribute 6 MMboepd to world energy supplies by 2000 and something over 30 MMboepd by 2025. Some sources, such as wind and solar energy, appear to be very attractive from an environmental point of view. Their role, however, is likely to be limited because of the relatively high cost of producing electricity from these sources. Solar energy for residential and commercial heating, biomass for power plants, the burning of municipal waste, geothermal energy in certain locations, wind energy in isolated locations, peat and some tidal and wave energy projects are all predicted to contribute significantly to world energy supplies, but there is no expectation that these energy sources can substantially replace conventional energy resources and nuclear power in world energy use even by 2025.

More technologically advanced energy forms such as nuclear fusion, satellite solar, ocean wave and thermal differences might make substantial contributions to world energy supplies by 2025, but no allowance is made for them in this assessment.

Role of substitution

The share of oil (and natural gas liquids), which accounts for about one-half of world primary energy production, might decline to just over 10 per cent by 2025. (See Figure 2-7.) Natural gas might decline from about 19 per cent to 6 per cent by 2025. Under those conditions, coal, which now provides 29 per cent of world primary energy production, might increase to 40 per cent. Nuclear energy, which provided less than one per cent in 1973, might increase to 37 per cent. Other sources (apart from hydro power), which made a negligible contribution in 1973, would increase to 4 per cent by 2025. Great variations are, of course, possible in these proportionate shares, but they emphasize that very substantial declines are expected in the next 25 to 50 years

1 "Uranium Resources Production and Demand, 1975"; OECD, Paris.

in the shares of world energy coming from oil and natural gas. Their place will be taken by coal, electricity (mostly nuclear, but also coal, hydro power and some renewables), and by a growing contribution from other resources, mostly renewables and byproduct energy. (See Figure 2-8.)

The patterns of substitution in world energy supply raise a number of important issues, among which are the extent to which:

- oil can be discovered, developed and produced, and the level of exports permitted by the OPEC nations;

- coal can be developed, used for thermal-electric generation, and substituted in industrial uses of energy;

- nuclear power can be developed and become accepted by the public so that supplies of it can increase substantially;

- coal exports from the USA and USSR are available; and

- renewable resources, byproduct energy and other new approaches to energy supply can be developed.

At the world level, if massive substitution can be achieved of coal and electricity for oil in industrial markets, of electricity, natural gas and other forms of energy for oil products in space heating, and of electricity and synthetic liquid fuels for oil in transportation, during the next 50 years, severe energy shortages at the world level might be avoided. <u>However, in order to achieve world energy balances in 2025, it is necessary to assume a vigorous development of all of the indigenous energy resources in each region, and a willingness to export from regions well endowed with energy resources</u>.

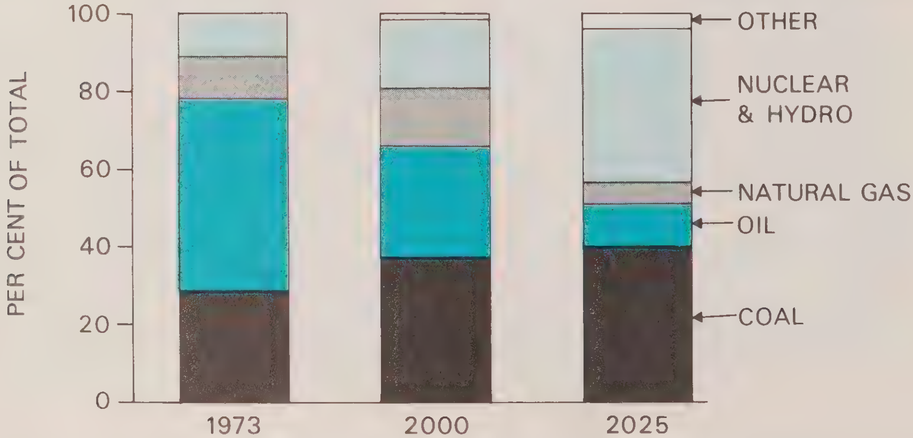
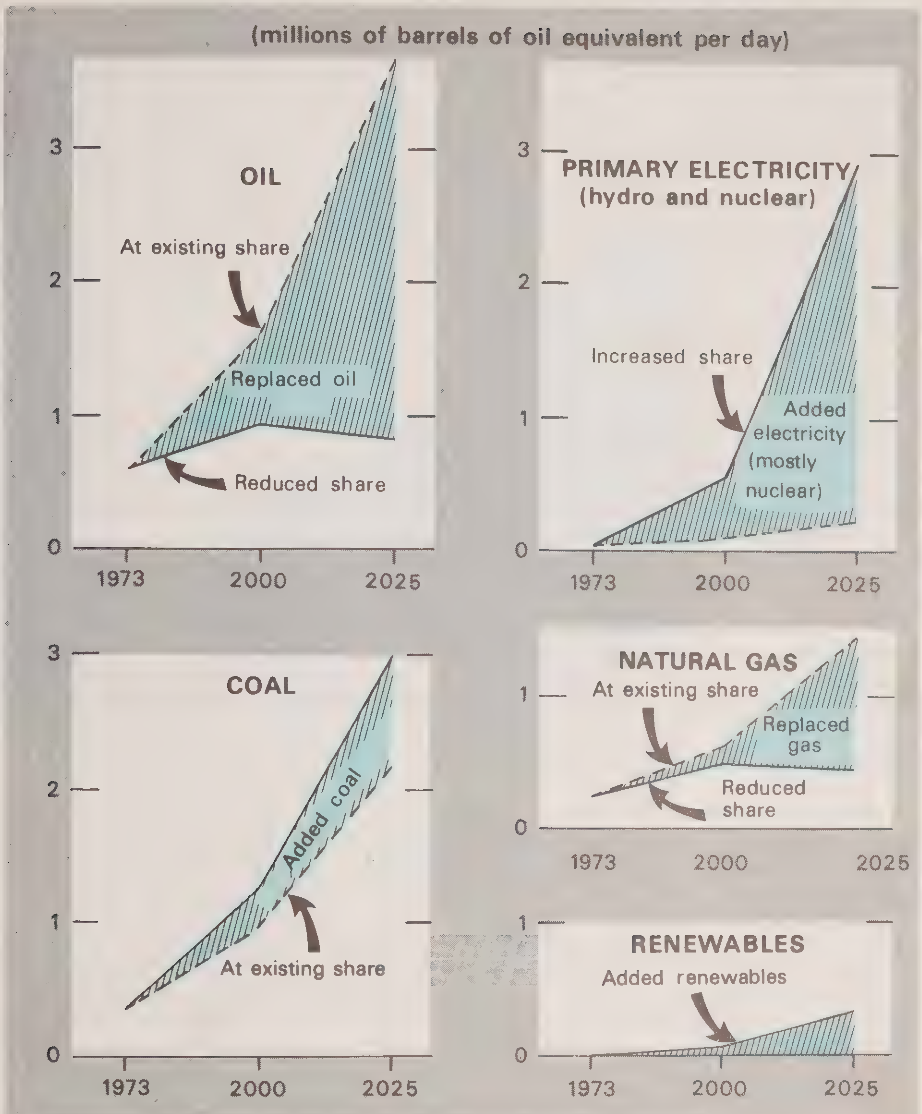


Figure 2-7. World primary energy production by source, 1973, 2000, 2025.



CHANGING MARKET SHARE (per cent)

	1973	2000	2025
OIL	49	28	11
NATURAL GAS	19	15	6
PRIMARY ELECTRICITY	3	16	39
COAL	29	38	40
RENEWABLES	—	2	4

Figure 2-8. World substitution for oil and natural gas.

World energy trade

Significant changes will occur in world energy trade patterns. (See Figure 2-9.)[1] A considerable volume of oil will continue to flow through world markets and, especially from 1985 to 2000, natural gas might play an important part in regional energy balances. After the year 2000, coal might displace oil, in volume terms, as the major energy commodity in world trade. No attempt is made here to identify inter-regional trade in uranium. In total, the volume of international trade in energy resources is expected to increase by substantial amounts, but difficulties of availability, transport and finance also will increase.

In terms of thermal equivalence, international trade might grow from 68 exajoules[2] in 1973 to 150 by 2000 and to 260 by 2025 -- almost a four-fold increase. By that time, coal might account for over two-thirds of the trade. Because of their dominance in coal, the USSR and the USA would be major exporters of energy by 2025, replacing the present oil dominance of the Middle East. In descending order, Southeast Asia, Western Europe, Latin America and Japan might be the principal importing regions, accounting for possibly 60 per cent of total world energy imports.

Oil

In 1975, total OECD consumption of oil amounted to 48 billion barrels per day, approximately 26 million barrels per day of which was supplied from OPEC sources.

By 2025 there may be the equivalent of 1.4 exajoules of electricity trade, primarily between Canada and USA, and between the regions of Europe and Africa.

Because of the substantial role of Saudi Arabia in OPEC oil production, and because that country is in a position to vary its production considerably, the contribution which Saudi Arabia might be called upon to make to world oil trade is examined separately from the trade potential of the other OPEC countries.

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1 Trade is here identified in terms of 16 regions:
Canada, USA, Latin America, Western Europe, Eastern Europe and USSR, Turkey, North Africa and the Middle East, Iran, Nigeria, South Africa, Central and Southern Africa, Indian sub-continent, China, Japan, other Asian countries and Oceania.

2 An exajoule is an international energy unit (see Glossary). By rough orders of magnitude, an exajoule can be considered as the equivalent of one "quad" of energy -- the measure used more generally in this report.

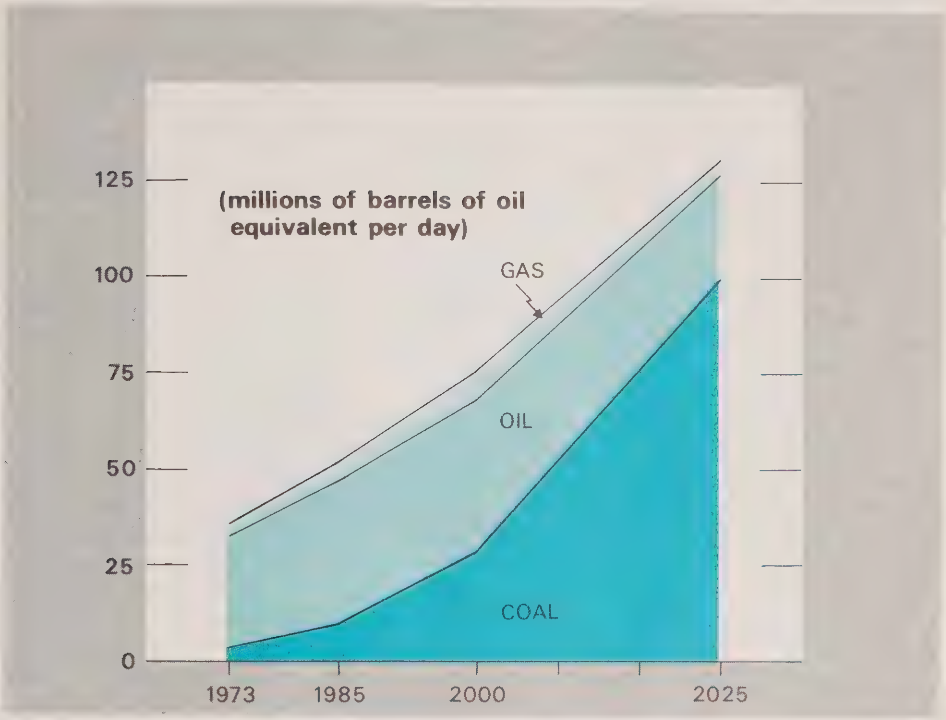


Figure 2-9. Inter-regional world energy trade.

As indicated in Table 2-4, the 1975 import requirement of OECD countries could have been met from the existing capacity of OPEC countries (28 billion barrels per day) other than Saudi Arabia. In 1975, Saudi Arabia produced some 8 million barrels per day compared with 20 million barrels per day for other OPEC countries. By 1985, the demands of the western world on OPEC, as depicted in Figure 2-10, would rise to approximately 44 million barrels per day (although plans are being made in OECD countries to keep demand well below that amount, if possible). Assuming that all the producing countries of OPEC, other than Saudi Arabia, were to operate at full potential in 1985, Saudi production would have to be 11 million barrels per day, nearly 40 per cent above its 1975 production. But only five years later, by 1990, total western consumption would have risen by an additional 10 million barrels per day. These demands could be met only if Saudi Arabia were to increase its production by an additional 12 million barrels per day. The table, therefore, helps to demonstrate both the swing position that Saudi Arabia can play and the possible difficulty in meeting western oil demands over the next decade and a half, even allowing for oil from the Alaska North Slope and the North Sea. <u>Even if other</u>

OPEC countries were to produce at capacity, Saudi Arabia's production would have to more than double between 1985 and 1990 unless western oil import demands can be reduced from the levels shown in Table 2-4. If other OPEC countries produce at only 75 per cent of capacity, as was the case in 1975, the production of Saudi Arabia in 1990 would have to triple -- to nearly 30 million barrels per day to meet western oil consumption requirements as shown in the table. Saudi Arabia might have little reason to produce more than 20 million barrels per day in the context of its own economic development plans and in consideration of maintaining satisfactory reserve-to-production ratios. At a rate of 30 MMbpd, Saudi Arabia would fall below a reserve-to-production ratio of 30 to 1 -- a ratio which any oil producing country might regard as too low in terms of resource conservation to meet longer term needs.

According to the world energy supply and demand analysis undertaken for this study, a much more tenable expectation is that production of conventional oil in the Middle East (including Iran) and in North Africa might increase to 35 MMbpd by 1985 and then gradually decline to 25 MMbpd by 2025, leaving total OPEC exports well below those which might be required by the western world by 2000 and 2025 unless western dependency on OPEC oil can be substantially reduced. Moreover, these estimates of availability to the western world have made no allowance for increased oil requirements by developing countries. The total volume of oil trade is expected to increase by about one-third by the year 2000 and to decline because of scarcity of supply to below present levels by the year 2025. In 1973, in terms of thermal equivalence, the world traded approximately 62 exajoules of energy in the form of oil. This could increase to 83 exajoules by 2000 and decline to perhaps 55 exajoules by 2025.

Natural gas

In 1973 less than two exajoules (about 2 tcf) of natural gas entered world trade. Over half of that originated in Canada destined for the United States. By 1985, over eight exajoules of gas (8 tcf) might be traded, based on existing plans for large diameter pipe (e.g. from Iran to the USSR) and greatly expanded liquefied natural gas facilities. By the year 2000, natural gas could account for 11 exajoules (11 tcf) of world energy trade, at which time Iran would be the most significant exporter. This assumes that most potential gas exporting regions, by that time, will be using gas in their own economy to the maximum extent possible. By 2025, no gas exports or imports are assumed to take place except for Iran which will continue to export some gas to the USSR by pipeline.

Thus, to take advantage of LNG in world trade, an importing country (including Canada) might expect the greatest availability of supply to occur between 1985 and 2000. In other words, imports

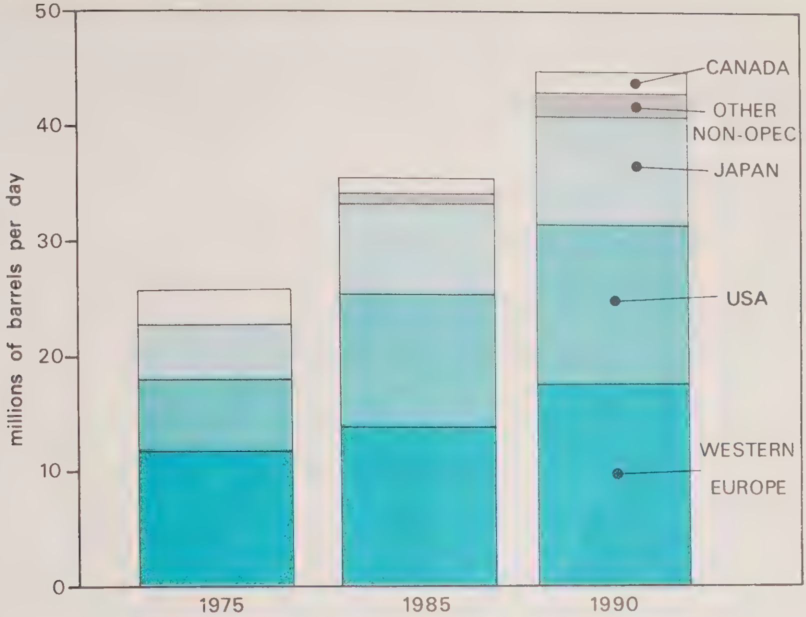


Figure 2-10. Western world oil requirements from OPEC.

TABLE 2-4

OECD World Oil Requirements From OPEC Countries

	1975		1985	1990
		(million barrels per day)		
Totals required from OPEC	26		35	44
OPEC consumption	2		4	6
Required OPEC production	28		39	50
OPEC capacity (excluding Saudi Arabia)[1]	28	(20)[2]	28	27
Required from Saudi Arabia[2]	-	(8)	11	23
Total Western consumption[3]	48		65	75

1 OPEC production capacity is shown, exclusive of Saudi Arabia, in order to highlight the necessary Saudi production, even if the full capacity of the other OPEC countries were used.
2 In 1975, Saudi Arabia produced about 8 MMbpd compared with 20 MMbpd for other OPEC countries. See figures in brackets.
3 Canada, USA, Western Europe, Japan and other non-OPEC countries of the western world.

of LNG in significant quantity might be regarded as a "stop-gap" while alternative supplies of energy are being developed. For Canada, imported LNG could supplement expanding domestic supplies of natural gas (including perhaps LNG shipments from the East Arctic), SNG and hydrogen.

Coal

In 1973, approximately twice as much coal (measured in terms of thermal value) entered world trade as natural gas. By the year 2000, world trade in coal could be of the same order of magnitude, in thermal terms and in physical volume, as the present world trade in oil -- possibly 57 exajoules of coal -- of the order of 2 billion tons of cargo. By 2025, exports of coal could increase to the equivalence of more than 220 exajoules (8 billion tons), according to our world energy supply and demand analysis. By 2000, the USSR could become an important exporter of coal, accounting (along with its East European neighbours) for more than one-half of world coal trade. Although the United States could accelerate production from its abundant coal resources, coal exports from the USA might not increase rapidly, at least before the year 2000, because of the growing coal requirements of the United States itself. It is conceivable that by 2025, the United States and the Soviet Union will share the gigantic world coal trade, at which time their role in world energy trade might be more significant than that of the Middle East today.

There are, however, serious limiting factors to the volumes of coal which can be produced, transported and used. There are physical difficulties and environmental problems which cannot now be adequately assessed in terms of such huge quantities of coal. Severe restrictions to the production, transportation and use of coal only serve to emphasize the extreme difficulty of achieving satisfactory world energy balances. Thus, while the expansion noted for the use of coal might seem to be impractically high, satisfactory alternatives might be even more difficult to implement.

Other energy resources

Electricity is not likely to play a significant part in regional energy trade, although purchases and sales between individual countries can be expected to increase appreciably in the future.

Uranium and other radioactive materials to supply nuclear energy will enter world trade in rapidly increasing amounts although, in volume terms, these nuclear fuels will not represent a substantial share of world energy trade. In value terms, they will be much more significant and could make a notable contribution to the export earnings of some countries, including Canada.

The required substantial increases in trade in uranium and other nuclear fuels can be expected, for many years, to continue to encounter difficulties because of concerns over hazards and safeguards. The longer the delay in reaching satisfactory international agreement on these important matters, the smaller will be the contribution of nuclear power to world energy balances for many years to come. As noted above regarding coal, constraints to the expansion of supply and use simply compound an already very difficult world energy balance outlook.

Renewable resources tend to be used or converted into other energy forms at or near the point of origin. Any trade arising from them, therefore, might be in the converted forms such as SNG and liquid or solid fuels.

Summary of world energy trade

The dominant position of oil as the main energy export and of the Middle East and North Africa as the main energy export regions will probably remain at least until the year 2000, allowing also for the export of natural gas from those regions. Beyond the turn of the century, the growing volume of coal exports could reach massive proportions if the difficulties of production, transportation and use of such huge quantities of coal are overcome. The Soviet Union and the United States might dominate coal exports. Nuclear fuels likewise will enter export markets in growing amounts, but the increase in physical volume will be less impressive than the increase in value of nuclear fuel exports.

A considerable increase in the volume and forms of transportation facilities will be called for. The logistics of moving substantially greater volumes of energy resources in international channels will pose major problems of planning, innovation and capital expenditure.

The necessary transitions in world energy trade cannot be expected to proceed smoothly. Shortages and regional imbalances of energy might well have seriously distorting effects especially over the next 25 to 30 years. There is, for example, little reason to expect that the supply of substitute energy resources, such as coal, nuclear fuels and, for a time, natural gas, will be available to readily match in a satisfactory way preferred or necessary changes in demand. The energy problems of some of the industrial countries might be as great as those for the developing countries. The potentially grave difficulties in the international trade adjustments in energy resources will have serious effects on Canada even if we are fairly successful in achieving a position of sustainable energy self-reliance by the year 2000. Some of Canada's international energy relationships are the subject of Chapter 3.

3. CANADA'S INTERNATIONAL ENERGY RELATIONSHIPS

Chapter guide

- *Although the principal objective is to achieve sustainable self-reliance in energy by the year 2000, Canada's international energy relations are expected to increase substantially from now to 2000, and from 2000 to 2025. These growing international relations are an integral part of satisfactory energy and economic performance in Canada.*

- *A prime objective is to eliminate the vulnerability of the Atlantic provinces and Quebec to disruptions of supply of imported oil, and to prevent imported oil from becoming a significant part of the energy supply of Ontario or other provinces.*

- *Beyond 1990, Canada might have a comparative advantage among industrial countries in the availability and cost of energy. Once long-term supplies are assured to meet Canadian requirements, the incentives to export energy resources and, more particularly, <u>energy embodied</u> in other goods and services will be high. Canada might achieve a net export balance in energy resources and in energy-intensive trade beyond 2000.*

- *Significant opportunities are likely to arise, permitting Canada to develop industrial and economic strategies based upon its relatively favourable energy position.*

- *The high levels of investment in energy projects in Canada to the year 2000 and beyond will require the inflow of investment funds in sizeable amounts. The funds likely will be available, but the incentives and conditions of ownership and control will differ appreciably from past and present conditions.*

- *Canada will be able to assist the developing countries to achieve a greater measure of self-reliance in energy. Technological innovations introduced in Canada will enable expertise, equipment and services to be placed at the disposal of the developing countries. The technolgical innovations, for example, might apply to resource evaluation and management, the production and use of renewable resources, transportation systems, nuclear and hydro installations, and to a wide range of energy-related economic, institutional, systems management, environmental, land-use and other social or community activities.*

- *Canada's participation in international R&D efforts, monitoring and regulatory agencies, and other international policies and programs will need to be greatly increased to gain full benefit from international energy developments.*

Chapter 3. CANADA'S INTERNATIONAL ENERGY RELATIONSHIPS

Canada and world energy balances

There are some close similarities between achieving satisfactory energy balances for the various countries and regions of the world and achieving them within Canada. For example:

- Drastic efforts will be necessary to achieve conservation, increased efficiency and structural changes in demand; these will be spurred by higher energy prices, the lack of the availability (or deliverability) of energy, and by the difficulties of substituting other energy resources for oil.

- The consumption of oil is expected to increase to 2000, then to level off or decline because of supply constraints; the share of oil will decline significantly in total energy use between 1975 and 2025 in Canada and on a world scale; this will create a need to increase substantially the use of other energy resources.

- Regional disparities in energy demand and supply will cause great difficulties in Canada and throughout the world; the volume of international trade in world energy resources (and transfers of resources within Canada) will increase far more for coal, natural gas and nuclear fuel than for oil.

- Electricity will increase significantly in relative importance in energy use; the increase being based mostly on nuclear power and coal, with some further increase in hydro power, and with contributions from solar, wind, peat, biomass, co-generation and other innovative energy supplies.

- Coal might meet more of the world's growing demand for energy than of Canada's because of proportionately more oil, natural gas and hydro power in this country; Canada might also be in a better position than the world as a whole to exploit renewable energy resources and byproduct energy.

- Capital expenditures and their financing, ownership and control will be dominant and difficult features of evolving energy systems, as will be environmental, land-use, health and other public and community concerns.

- Renewable energy resources, byproduct and waste forms of energy will be developed rapidly on a world scale and in Canada, but their contribution will be modest in terms of total additional energy requirements.

- Plans should be made to establish as much energy self-reliance as feasible by individual country (or province in Canada) and by regions; this approach is not isolationist but is essential to satisfactory energy balances; without greater reliance on indigenous resources, world energy supply and trade problems could reach insuperable proportions.

- World trade in energy resources can be expected to increase by massive volumes even if countries achieve a high degree of energy self-reliance.

- It will be extremely difficult for many countries to maintain satisfactory economic performance and make further gains in individual and social well-being, given the evolving energy situation; the same will be basically true for Canada, even though its energy outlook is much more favourable than that for most other countries.

Objectives and targets

The principal objective of Canada's international energy relationships is to support the economic and social well-being of Canadians. A second objective is to contribute as much as possible to easing global energy problems, most particularly those of the developing countries. These objectives are supported by the following targets in Canada's international energy relationships. These targets might be achieved by the year 2000, and would represent a direction of movement between 2000 and 2025. Their achievement by 2000 requires that ambitious programs be developed and implemented from now forward.

The principal targets are:

International trade and aid

- eliminate dependency on imported oil by the year 2000 or soon after;

- work toward a net export in energy resources, energy-related equipment, skilled services and technologies by 2000 and beyond;

- by developing exports and import-replacements of energy-intensive goods and services, exploit Canada's growing comparative advantage in energy;

- use Canada's growing expertise and technology as a source of international earnings; and

- put Canada's energy problem-solving experience at the disposal of developing countries to help them achieve greater energy self-reliance.

International financing

- ensure that new financial arrangements and associated conditions such as ownership, control, taxation and regulations, as implemented by the energy industries, the financial institutions and governments in Canada, provide the incentives for the inflow of requisite financing for energy projects; and

- participate in international financial projects supportive of Canada's long-term energy objectives.

Balance of payments

- ensure that current and capital account energy transactions, such as those referred to above, tend to contribute positively to Canada's balance of international payments.

Other international energy relations

- participate as fully as possible in international R&D, and in other programs and agreements to ensure that these international activities contribute fully to clearly articulated, long-term energy objectives for Canada.

It is important to recognize that the above targets treat the energy sector as an integral part of Canada's total trade, aid, financing and other international relations. The energy sector, directly and indirectly, probably can make a net positive contribution to Canada's international balance of payments. That objective can be an explicit goal of energy and industrial and economic policy. The necessary energy-related programs involve substantial commitments of expert manpower and of financing, but they also offer important opportunities to pursue a wide range of economic objectives, including industrial development, employment and regional development.

Energy can become a major dynamic for restructuring the Canadian economy and Canada's international relations in ways which will allow us to help to meet the growing world demand for goods and services. Moreover, Canada's energy policies, institutions and systems can serve as models for others, particularly for some of the developing countries. There are also many specialized skills, technological innovations, emergency supply and substitution programs and energy financing programs in which Canada can make a valuable international contribution. Some of these relationships are illustrated in Figure 3-1.

If a high degree of energy self-reliance is obtained in Canada, the importance of world energy balances and international energy relationships to this country will derive not just from the energy balances themselves but also from their economic,

social and geopolitical ramifications. These will affect our relationships with the oil exporting countries, the possible coal exporters, with the other industrial countries, both bilaterally and multilaterally. Energy and economic relationships with the developing countries will become increasingly important. The interdependence of all nations will be greatly increased in striving for appropriate world energy balances.

International trade, financing and ownership

The external energy account, current or capital, will not necessarily be kept in balance. However, given Canada's energy resource endowment, substantial deficits on energy trade should be avoidable. Exports of energy resources, technology and of energy-intensive commodities can be deliberately developed to offset other trade and payments deficits. Thus, a policy of energy self-reliance does not preclude exports and imports of energy and energy-related goods and services when economic and other national-interest considerations warrant.

The final section of this chapter deals in more detail with Canada's international trade. In brief, Canada's energy trade (although still showing an export surplus) is expected to enter a deficit position. That deficit could increase to a disturbing extent if no action is taken to reduce reliance on imported oil. By 1985, the deficit on oil account might be $4 billion to $6 billion (even without further increases in the price of oil). It could then place a severe burden on Canada's international balance of payments. Paying for the oil deficit would deprive Canada of corresponding access to other imports and would restrict the availability of domestic production to our own use. Although Canada's oil imports would place purchasing power in the hands of the oil exporters, their propensity to import (directly or indirectly) might make the terms and conditions of trade unfavourable. Unless programs are adopted to increase Canada's energy self-reliance, a very sizeable energy trade deficit could greatly constrain our choices. On the other hand, Canada's relative advantage in energy among the industrialized countries indicates that dynamic industrial policies can be pursued based upon that energy advantage. Such policies could greatly improve Canada's international trading position beyond 1985 or 1990.

Beyond 1985, the availability of oil in world energy markets is expected to become increasingly precarious. Heavy reliance on imported oil could place Canada (and other countries) in an increasingly vulnerable position. Also, the expected substantial increases in world oil prices will mean that Canada's energy resources can be developed on an increasing scale at competitive prices. Because of the long lead times required to bring those resources on stream, advance preparation should now be pushed as aggressively as possible to ensure that full advantage can be

Figure 3-1. Canada's growing energy links with the world.

taken of that later situation. The attempt to reduce oil imports is not premised chiefly on trade or balance of payments considerations, but on the probable severe constraint on availability of world oil beyond 1990.

A brief outline of investment and financing needs for energy systems is given in Chapter 10. Capital funds are expected to be adequately available in world financial markets, and the usual commercial considerations are expected to substantially determine the international sourcing and disposition of funds, although

under more disturbed and uncertain conditions. Private intermediation will confront greater government regulation, financial participation, intervention and control not only in Canada but also abroad. Keeping conditions in Canada relatively attractive to large capital inflows will be an important element of policy.

International and national financial consortia will be increasingly appropriate for many of the especially large energy projects. The lower availability of Canada's oil and natural gas resources for export will reduce considerably the incentives for foreign financial participation. However, new opportunities can be developed for a wide range of energy and industrial projects which involve international participation. In some instances, an "assured supply" provision will be the most attractive feature for external sources for funds. Conditions of ownership, control and participation will alter appreciably, and will require adequate incentives to private industry and financial institutions in Canada and abroad. The active participation of the federal and provincial governments in financing, control and management will become increasingly important both directly in the energy projects and indirectly in the provision of incentives and a measure of risk alleviation for the private sectors. Substantial revision of the attendant institutions, regulations and management systems would benefit from extensive consultation involving the energy industries, financial institutions, governments and others, starting now.

Ownership and control will not accompany the inflows of capital from abroad to the same extent as in the past. The use of more debt instruments rather than outside equity will tend to uncouple financing from ownership. In addition there should be more Canadian equity participation. However, foreign equity will still have an important role to play. Regulation and control will have to be properly handled so as not to inhibit outside equity participation.

International technology

Many new technologies, institutions and international arrangements are required if new sources of supply and increased efficiency in use are to be achieved. Coordinated international efforts are beginning to assist in the process. In the face of the increasing vulnerability of most countries to the limited availability of international energy supplies, international consultative and control activities need much further extension if they are to become fully effective over the next 10 years.

Canada's participation in R&D programs and in consultative and control agencies will be increasingly important to our adjustment to world energy conditions. The participation, at times, will be

bilateral (e.g. with United States on Arctic energy exploration, production and transport, or with Venezuela on heavy oils or with Japan and countries of Western Europe on energy, industrial and trade programs). Some will be multilateral, such as Canada's participation in the International Energy Agency (IEA), with reference to emergency allocation, technological innovation, energy conservation and environmental and safeguard considerations.

Canada's international R&D priorities are an extension of the priorities of the domestic energy requirements. Efforts undoubtedly will be directed principally to those areas of research in which Canada will receive the greatest benefit. Indigenous programs, such as CANDU, large-scale hydro projects, oil sands and heavy oil developments, amply demonstrate Canada's capacity to take initiatives which can yield international benefits. Similarly, Canada's research efforts and technological advances might be expected to be in the forefront of world efforts in a number of other fields -- for example, in Arctic oil and gas exploration, geological resource assessment, pipeline and tanker transport, Arctic environment and land-use technology, oil sands technology, energy systems management and institutional change, space and water heating, remote community energy systems, public participation and energy information programs, seasonal storage, long distance transport, financing arrangements, transmission and communications. Participation in international research efforts will also enable us to adapt the most advanced world-wide technologies as early as possible to Canada's particular requirements.

Highly qualified manpower and financial support for R&D, technological testing and implementation are scarce resources, both within Canada and on a world scale. Even those areas of research which relate most closely to our own priorities can overtax our available pools of experts and financial resources. Hence, carefully worked out programs and priorities will be needed to increase the scientific and skilled manpower and the financial commitments to R&D and to technological innovation in energy-related activities if Canada is to take full advantage of world technological developments. The federal government has a key coordinating role in bringing provincial agencies, industry and other research centres fully into international R&D activities. The integration of Canada's R&D efforts with international R&D will greatly benefit from consensus on national energy priorities.

International Energy Agency (IEA)

Canada is an active participant in the IEA, established in 1974, as the principal energy research coordinating body for the OECD. It offers a particularly convenient forum for participating countries to advance technologies in energy systems. The IEA research priorities are consistent with Canada's objectives. They include technological contributions to:

- effect a slowing in the rate of growth in the use of energy;

- promote interfuel substitution and the requisite industrial base for the use of substitute fuels;

- make more use of renewable energy resources on a world-wide scale; and

- share the world's limited technological and financial resources to meet long-term energy needs.

Energy technologies and developing countries

A new agency has been recommended -- an International Energy Institute -- organized under the United Nations to assist with the energy problems of the developing countries. Problems remain of defining the scope of the R&D, of establishing management, and of implementing working relations among the countries. The management of intellectual property, much of which is within private companies, is an additional dimension to technological and research problems, already of bewildering complexity. There is no reason for Canada's participation to be confined to the proposed Institute. Canada will be in a position to offer assistance on a bilateral and multilateral basis directly to the developing countries.

Three features of international R&D and of coordinating and control agencies merit special attention:

- The scope of research, coordination and control being brought within systematic international approaches is continuously broadening, and is being assessed in increasingly comprehensive ways; further extension of these activities will greatly alter energy systems, international trade and other international energy relations.

- The potential gains to Canada of active participation in international programs are great, as are the contributions which Canada can make to such activities.

- Canadian financial and skilled manpower resources will have to be greatly increased if adequate allocations are to be made to international activities and to their coordination with Canadian energy programs. There is no free ride. The much broadened concept of R&D which is emphasized for Canada (Chapter 11) is also relevant to international R&D activities. It requires that demonstration and commercial deployment projects and, hence, management systems be included as part of technological innovation (RD&D), and that R&D activities extend to economic and social factors in order to remove constraints and exploit opportunities wherever they exist within a coordinated, comprehensive energy program.

Energy and Canadian trade

In the past, satisfactory energy balances in Canada have been achieved by recourse to imports of oil and coal. These have long been an important component of Canada's energy supply. Since the National Oil Policy was introduced in 1961 the oil supply-demand balance has been maintained in part by exporting oil and natural gas from western Canada, encouraging the use of Canadian oil and gas in Ontario, and importing oil into the Atlantic provinces and Quebec. In much the same way, coal is both imported and exported, with the value of imports still in excess of the value of exports. Uranium and electricity exports are making an increasing contribution to Canada's international earnings.

Energy can be exported in this form or embodied to a greater extent in other goods and services.

Table 3-1 sets out some indicators of Canada's overall trade performance from 1966 to 1976 as a backdrop for considering aggressive industrial and trade policies and the importance of primary resource exports to the maintenance of a satisfactory trade performance in the future. As indicated in the first column of the table, there has been a general decline in Canada's share of world exports from the levels of the late 1960s and

early 1970s. This has been accompanied by a significant rise in imports as a per cent of domestic spending. The balance of merchandise trade as a proportion of GNP generally declined during the first half of the 1970s and the total of goods and services ran a larger proportionate deficit in 1975 and 1976 than in earlier years.

TABLE 3-1

Indicators of Canadian Trade Performance, 1966-76[1]

	Trade shares (per cent)		Trade balances (per cent of GNP)		
	Can. exports / World export of goods	Can. imports / Domestic spending on goods	Goods	Services and transfers	Total
1966	4.9	22.9	0.4	-2.2	-1.9
1967	5.2	12.8	0.9	-1.6	-0.8
1968	5.5	25.4	2.0	-2.2	-0.1
1969	5.3	26.9	1.2	-2.4	-1.2
1970	5.4	25.7	3.6	-2.3	1.3
1971	5.3	25.8	2.7	-2.3	0.5
1972	5.1	27.7	1.8	-2.1	-0.4
1973	4.5	29.0	2.2	-2.1	0.1
1974	4.1	32.6	1.2	-2.2	-1.0
1975	3.8	31.9	-0.3	-2.6	-2.9
1976	4.2	30.4	0.6	-2.8	-2.2

1 Derived from "The Availability of Capital to Fund the Development of Canada's Energy Supply", J.R. Downs, Study No. 1, The Canadian Energy Research Institute, Calgary, 1977, p. 10. (Negatives indicate imports greater than exports.)

As noted in the recent study for the Canadian Energy Research Institute, "the improving trend in 1976, and in 1977 when the merchandise surplus will be roughly 1.3 per cent of GNP, owes too much to foreign and Canadian business cycles and too little to an improvement in Canadian competitive performance". (See footnote Table 3-1.)

Further evidence of this deterioration in competitive performance is the three-fold increase Canada has experienced between 1970 and 1975 in net imports of higher technology manufactures.

Net Imports of Higher Technology Manufactures

(million dollars)			
1970	1974	1975	1976
2 319	6 969	7 669	7 196

In 1976, only three out of the 19 Canadian industries which are classified as producers of high technology goods recorded net exports. The largest of these, the petroleum and coal products group, had net exports of $350 million.

In terms of net trade balance, raw materials and semi-fabricated products have been the strongest performers over the past two decades, and it is these groups, and net capital inflows, that have permitted Canada to pay for its net imports of services and manufactured products. The net contribution of raw materials to Canada's balance of payments increased by nearly ten-fold over the 14-year period, from $0.5 billion in 1960 to $5.0 billion in 1974. While significant continuing growth can be expected in non-fuel minerals and forest products, prospects for the category as a whole over the next 10 years are not as encouraging as they were during the last decâde, particularly if a large deficit is incurred on the energy account.

As shown in Table 3-2, over the past decade and a half Canada's international trade in energy materials moved from a deficit to an export surplus. At their peak, from 1974 to 1976, exports of energy resources were contributing well over one billion dollars a year to Canada's trade balance. By 1976, Canada's international trade in oil and oil products was in substantial deficit which, however, was still more than offset by the increasing value of exports of natural gas, entirely as a result of higher prices. Physical quantities of exports of natural gas have been declining since 1973.

Future energy trade prospects

Historically, imports of oil have been the final "fallback", to make up for any shortfall in domestic energy resources. That was a highly satisfactory adjustment in the pre-1973 circumstances.

TABLE 3-2

Energy Trade Balance[1]

	1960	1973	1975	1976	1977
	(million dollars)				
Oil and products					
Exports	104	1 782	3 686	2 836	2 387
Imports	396	1 135	3 510	3 450	3 486
Balance	(292)	647[2]	176	(614)	(1 099)
Natural gas					
Exports	18	351	1 092	1 616	2 028
Imports	2	8	8	9	-
Balance	16	343	1 084	1 607	2 028
Oil and gas balance	(276)	990	1 260	993	929
Coal and coke					
Exports	11	177	482	566	609
Imports	80	181	627	570	660
Balance	(69)	(4)	(145)	(4)	(51)
Electric energy					
Exports	16	109	104	162	377
Imports	1	7	13	9	15
Balance	15	102	91	153	362
Radioactive ores					
Exports	-	64	47	67	75
Total exports	149	2 483	5 410	5 247	5 476
Total imports	478	1 332	4 158	4 038	4 161
Balance	(330)	1 151	1 252	1 209	1 315

1 Bracketed figures are trade deficits.
2 Peak in 1974, $1036 mn.

However, the passive acceptance of an oil "fallback" solution to energy imbalances already has ceased to be a satisfactory solution and each year that passes can only make it increasingly unsatisfactory. The current, short-term availability of world oil lulls us into a false sense of security encouraging oil imports. The need to break away from passive reliance on imported oil will become a major cause of long-term energy adjustments. Government policy now recognizes that unlimited reliance cannot be placed on imported oil. However, public support for energy self-reliance is not much in evidence.

Adjustments away from imported oil have to be undertaken even before the world oil situation demonstrates conclusively that such adjustments are necessary. Public support in all provinces -- producing and consuming -- will be needed for policies, the critical need for which is not yet fully demonstrated. Dynamic, aggressive programs to move progressively away from reliance on imported oil will involve uncertainties and risks which are extremely small compared with those of inaction at this time. Public acceptance of, and active participation in, programs for energy self-reliance is a top national priority.

The necessary adjustments, properly carried out, can improve Canada's competitive position. The critical objective is to avoid an ever-increasing dependency on imported oil. Both exports and imports of energy resources and energy-related goods and services can be expected to increase (under much more controlled conditions). However, Canada's net energy trade position should not be one that leaves us vulnerable to the vagaries of world energy supplies as these enter international trade.

Well before 1985, Canada's trade deficit on oil is unlikely to be offset by the surplus on natural gas. The deficit on the combined products might approach $2.5 billion in 1985. Beyond 1990, with only very small exports of natural gas, the net deficit could be many billion dollars unless substantial efforts are made to reduce oil imports. Even the announced target of imports of only 800 000 barrels per day could mean a deficit of more than $6 billion a year especially as oil prices increase, and that target will not be achieved easily. Some increase in exports of heavy oils from western Canada would not likely bring the deficit on oil trade below $6 billion after 1985.

The absence of the imported oil "fallback" places more emphasis on the need to have assured energy supplies from Canadian resources to provide for 20 to 30 years of future requirements. Flexibility and back-up will be provided by developing a broad range of resources at the same time. The need for long-term, assured supplies and to provide reserves for security and flexibility will require that exports of energy resources be restricted as, in fact, already is being done. Control over exports can be expected to become an even more stringent part of Canada's

energy and trade policies. This applies not just to oil and natural gas, but to uranium, coal and electricity as well. Spot exports and short-term contracts can be expected which will even out temporary surpluses and assist orderly marketing. As a general rule, energy can be expected to be incorporated into products which, in turn, are exported rather than be part of an expansive export objective as energy resources.

In spite of the above strictures, both imports and exports of energy resources and energy-related goods and services can be expected to increase appreciably, particularly between now and the year 2000. Oil, coal, uranium, natural gas and electricity will figure prominently in that trade. Beyond 1990, a moderate export surplus in energy resources might re-emerge if the trade deficit on oil is reduced. Export earnings from energy-related professional and skilled services and from Canadian designed and manufactured equipment for energy projects can be expected to increase if aggressive development and marketing policies are adopted. Canadian financial services to other countries might also accompany energy-related sales in greater amount. To an increasing extent, beyond the year 2000, more readily accommodated adjustments are expected to place in trade and in other international relations associated with energy. The danger, on the one hand, is that too passive a reliance on imported oil and coal will dull our efforts to meet domestic challenges and, hence, will subsequently cause disruption and distress. An uncritical reliance on imports of energy resources could cause us to miss great new opportunities within Canada. The danger, on the other hand, is that we will fail to take advantage of export opportunities, even short-term, to effect better energy balances and higher incomes for Canadians.

The above matters are receiving increasing attention by governments, industry and the public at large. Nevertheless, the long-term implications of the international trade setting are so profound for Canada's future well-being that they are identified as a strategic issue area[1] for urgent and thorough policy investigation in a comprehensive way.

Energy for developing world

Canada has established a reputation for excellence in the export of large energy supply systems (e.g. hydro, electrical equipment and CANDU reactors), and specialized resource services such as geological surveys and resource evaluation. Canadians have also had a visible participation in energy-related aid programs to less developed countries. The plight of the developing

1 See Appendix 3.

countries in the scramble for very expensive world energy commodities can be expected to become a matter of increasing world concern. Canada, while developing its own great and varied energy resources under very difficult and experimental conditions, will have a unique opportunity to fulfill its international responsibilities to the developing countries. This is true not just for individual energy projects but also for the establishment of new energy balances in developing countries within a concept of a national energy program such as here proposed for Canada. This activity, in time, can also open up new, mutually advantageous commercial opportunities.

4. WHAT ENERGY DO WE NEED?

Chapter guide

- *In looking at Canada's future energy demand, four principal objectives emerge:*
  - *a) within a careful, disciplined application, energy is to sustain satisfactory economic growth and enhanced individual and social well-being in Canada;*
  - *b) a much lower growth in energy demand must be accompanied by a transformation of energy end uses to match future supply capabilities -- the energy we can have;*
  - *c) the annual rate of growth in energy demand is to be reduced so that, between 1977 and 2000, it averages only one-half the rate of the past 20 years (5.3 per cent), and reduced by at least one-half again between 2000 and 2025 (even so, twice as much energy will be required in 2000 than is currently being used); and*
  - *d) the moderation of demand would result from a lower rate of population and economic growth; conservation measures and increased efficiency, and from structural changes to further modify increases in demand. Patterns of demand would be altered so that the share of oil is reduced from about 45 per cent of total use to 30 per cent by 2000 and 25 per cent by 2025; more use would be made of electricity, natural gas and renewable resources.*

- *Much higher energy prices will help to ensure more careful use of energy, but other incentives to economize its use, and disincentives to prevent wasteful use, will be necessary.*

- *Five principal programs are envisaged to help to reduce energy demand and to permit other energy resources to be substituted for oil. They deal with energy according to its functional characteristics -- low-temperature heat, high-temperature (process) heat, stationary mechanical drive, mobile mechanical drive, lighting and appliances. These are <u>national</u> programs with indicative targets for each. They also explicitly consider provincial and regional differences; they involve participation by all Canadians. The programs are components of a broader objective of "structural changes to achieve new energy balances". The five programs are:*
  - *a) space heating program;*
  - *b) transportation energy program;*
  - *c) industrial energy program;*
  - *d) consumer products energy program; and*
  - *e) community energy design program.*

- *The above programs are supportive of a national economic and social opportunities program designed to ensure that the new energy balances provide new opportunities for Canadians.*

Chapter 4. WHAT ENERGY DO WE NEED?

The amount of energy which a society needs (or wants) is largely determined by the wealth to which the society aspires, how well its affairs are organized and managed and, finally, the amount of energy available and its price. The demands for energy are derived demands, determined by the confluence of the aspirations and achievements of society. Energy is the servant of society and of personal comfort and convenience. Over the past 30 years, the abundance and relative low cost of energy imposed almost no limits on economic and social choice in Canada or in many other countries. In the future, the choices open to society will be greatly restricted by energy supply conditions. That transformation from an energy-independent to an energy-constrained society is the principal focus of energy-demand considerations.

The forces of change are confronted by the profound commitments of society to its present patterns of energy use. These, as an expression of society's past and present preferred lifestyles, will normally change slowly. However, the future reversal from almost unconstrained increases in the use of energy to severe energy constraints represents a transformation unprecedented not just for Canada but for the entire industrial world. It is a difference not just of magnitude but of kind. The transition could be forced on us in very disruptive ways unless long-term transition is well planned and well executed. Looking back over the past 50 years, the magnitude of change has been tremendous. However, apart from the highly disruptive impacts of war and world-wide depression, the changes progressed fairly automatically from the economic, industrial and community structures of 50 years ago. Even though the changes over the coming 50 years are expected to be even greater and more difficult than those of the past, the evolution of society and the economy, barring major disruptions, will move progressively forward in recognizable ways from the present base. One major difference is that, whereas in the past 25 or 50 years the use of energy was toward more abundant, efficient, convenient and lower cost forms, in the future, demands for energy will confront less abundant, less convenient and much more expensive forms. Thus, society and the economy, instead of experiencing the dynamic thrust of substituting more preferred forms of energy, will have to wrestle with the problems of dealing with increasingly restrictive energy supplies. What is more, oil, that energy form so basic to our present industrial structure and wealth, will be most constrained.

This assessment concludes that Canadians should plan now for serious restrictions to energy supply, possibly by 1985, but certainly not long after. The adjustment time is short in the

extreme. Moreover, the present public perceptions of a fairly easy energy situation offer few incentives to begin a difficult, but essential, long-term transformation. Although many measures are being taken to introduce greater energy conservation and changes in energy supply, the requirements of the longer term are seen to be of an entirely different order of magnitude.

A basic objective of a long-term energy program is to ensure that social well-being is enhanced within a much more disciplined approach to the use of energy, under the greatly altered conditions of energy supply. If this objective is pursued as a high national priority, a dynamic economic and social future can emerge in Canada.

Modifying energy demands

<u>At least half of the necessary adjustment to a severely constrained energy situation can come about by reductions in the rate of growth in demand</u>. Three main factors can reduce the growth in energy demand and the need for imported oil:

- <u>a slow-down in the long-term rate of increase in economic growth</u> in ways which represent satisfactory economic performance; the principal impact of lower rates of economic growth will come after 1990;

- <u>intensified efforts of conservation and increased efficiency</u> which will have their principal impact between now and 2000; and

- <u>structural changes in patterns of energy use</u> to be put in place from now on, but which will have their principal impact after the year 2000. These changes can be centred around the five principal energy programs noted above.

<u>An essential requirement is to reverse the present trend of increasing reliance on imported oil, particularly in Quebec and the Atlantic provinces</u>, the regions now dependent upon imported oil. If patterns of supply and demand were to continue on past trends, imported oil would also soon be required in Ontario. Very substantial changes in patterns of energy use across most of Canada are needed to forestall that eventuality.

New demand patterns are far from costless. For example, as only part of the requirement to insulate older homes, the federal government in its Canadian Home Insulation Program (CHIP) has announced grants totalling up to $1.4 billion. That is perhaps less than one-third of the total cost of building insulation, and that, in turn, is only one part of a much longer program of demand adjustment. The costs in time, effort and money of making substantial modifications to patterns of energy demand might seem

to be high at this time to a society not accustomed to severe energy constraints, and not fully convinced that serious restrictions in energy supply will occur. However, the changes will be inevitable. The costs of making adjustments to energy demand and supply by carefully prepared programs of adjustment will be inconsequential compared with the costs of not planning in advance the adjustments which will be necessary.

Society should be under no illusions about the probable costs of failure to adjust to the constrained energy situation which appears to confront Canada and most of the world beyond 1990. There is no likelihood that rates of increase in energy demand approaching those of the past 20 years could continue without soon running into severe shortfalls of energy supply. Even the much more moderate demands postulated in this assessment could place almost insupportable strains on the supply of energy beyond 1990. The costs of failure to adjust can include severe disruptions and shortfalls of energy supply. These could result in black-outs, interrupted production, and constraints on personal freedom of choice. These disruptions could require that energy supplies be allocated or rationed on a scale reminiscent of wartime controls. Some regions and sectors of industry and society would inevitably be more severely disadvantaged than others, and acute distress and inequity could result. In extreme circumstances, economic and social order and the institutions supporting society could be tested perhaps to the point of breakdown.

Figure 4-1 illustrates the three main factors which make for moderations in the demand for energy -- lower economic growth, conservation and increased efficiency, and structural changes. There is considerable scope for changes of this kind without much strain on society. Beyond some level, however, the magnitude of the transitions would produce severe stresses and strains. A satisfactory energy balance, therefore, becomes some appropriate equilibrium of the stresses and strains resulting from efforts to reduce energy demand and of those associated with increasing energy supply.

Dimensions of change

The dimensions of energy supply and demand are expressed in "quads" of energy.[1] To appreciate the magnitude of a "quad", it might be noted that in 1977 Canadians, in spite of using more energy per person than most people of the world, used only 5.5

1 One "quad" is a "quadrillion" British Thermal Units of energy (1 000 000 000 000 000 or 10^{15} BTUs); an exajoule in the metric system is about equal to 0.95 quads. See the glossary.

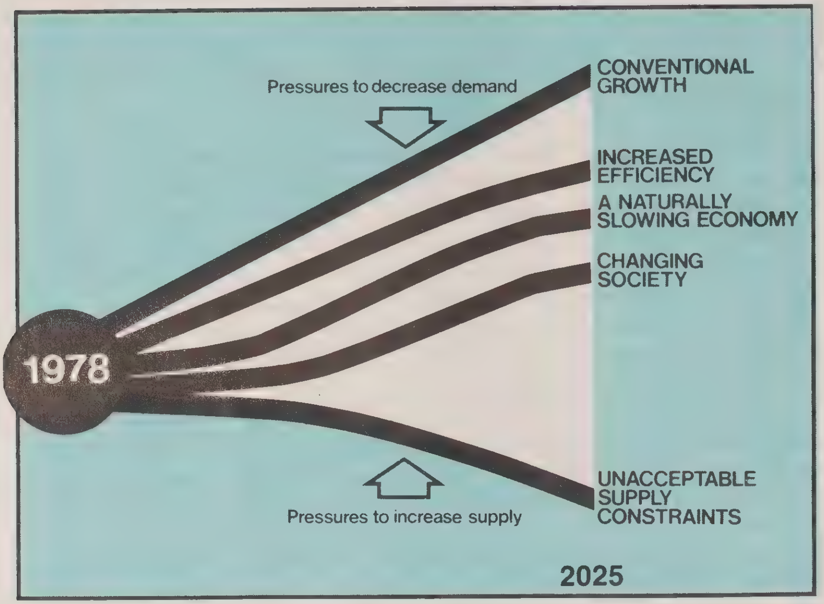


Figure 4-1. Illustration of changing demand.

quads of delivered (secondary or net) energy. That net energy required 8 quads of "primary" energy (before allowance for conversion and production losses). The 8 quads of primary energy is about the equivalent of nearly 4 million barrels per day of oil, more than twice the Canadian production of crude oil in 1976.

In other words, one quad of energy is a very substantial amount -- about as much as that used by all of the cars in Canada in a year. To provide an additional quad of energy is, therefore, a sizeable task. To be able to reduce demand by one quad is a substantial saving, one that very appreciably eases future energy supply problems, especially when its effect is considered year after year.

Demands for energy in Canada increased at about 5.3 per cent a year from 1960 to 1975. Even at a growth rate of 3 per cent a year between 1977 and 2000, Canadians would use nearly twice as much energy in the year 2000 as in 1977. At a growth rate of only 2 per cent, there would be a saving of 3.2 quads of primary energy in the year 2000 from what would be used at a growth rate of 3 per cent. That saving represents the equivalent of 10 large oil sands plants, or 40 Pickering-type nuclear reactors. The cumulative saving from 1977 to 2000 would be about 40 quads, or five times all the energy used in Canada in 1976. Savings of that

magnitude represent a crucial easing of the burden of energy supply. Even after such savings, however, the actual quantity of energy required is much higher year after year than it is at present.

Indicators of change

Table 4-1 sets out some of the principal indicators of economic and social change. Behind these simple indicators are the complex happenings of a progressive, rapidly changing society. Any number of different magnitudes of change might be used for these indicators. Some of the other combinations would represent an easier process of adjustment; other combinations, a more difficult adjustment. However, no other combination of changes which seemed reasonable within this assessment materially reduced the magnitude of the transition nor the difficulty of the task. For that reason, only one combination is used to illustrate the magnitude of the future difficulties. The challenge is to find any other combination more likely, less difficult and more satisfactory.

Table 4-1 provides an assessment of the future growth in Canada's population, gross national product and energy requirements. The rate of increase in the use of energy, 2.8 per cent a year for primary energy between 1975 and 2000, and 2.4 per cent for secondary (or net) energy are about one-half the rate of increase from 1960 to 1975. The rates of increase in the use of energy from 2000 to 2025 are less than half those from 1975 to 2000. Reasons are outlined below as to why these much reduced rates of energy growth could still yield satisfactory economic performance and enhancement of individual and community well-being for Canadians.

Even with the much reduced rates of growth, the use of energy doubles between 1975 and 2000, and increases by a further 25 per cent between 2000 and 2025. Thus, in terms of the physical quantities of energy to be supplied, the future holds no easy solution even with the lower rates of increase in the use of energy. Without strenuous efforts to moderate demand to such an extent, the provision of satisfactory energy supplies would impose perhaps insupportable strains. Some of the implications of the increased energy requirements are outlined in Chapter 6 in terms of energy balances. This chapter is devoted to factors and programs which will help to reduce the growth rates in energy demand, and keep total requirements within the magnitudes shown.

In Table 4-1, the rate of increase in population and in Gross National Product (GNP) are lower from 1975 to 2000 than from 1960 to 1975, and lower again from 2000 to 2025. Economic growth can be expected to slow from the high rates of the past 25 years as a result of a lower rate of population increase, the aging of the

population, changes in participation rates, income redistribution and the maturing of the economy. Rates of increase in real incomes are shown as lower than in the past, but are regarded as generally satisfactory, given the more mature society and the difficulties of the economic and energy adjustments.

Lower population growth

Even with the slower rate of population growth, Canada's population would increase nearly 30 per cent by 2000. The rate of growth slows even more between 2000 and 2025. The great upsurge of young people in the population since the Second World War is already passing into older age groups. New entrants into the labour force will be fewer relative to population and, after allowing for changes in work habits and forms of employment, they probably can be fully employed in ways which moderate the increase in the use of energy. Immigration also is assumed to add relatively fewer people to Canada's population than from 1950 to 1975.

Aging of population

This maturing process can itself have a significant effect on the amount of energy used and the patterns of use. For the most part, the net effect probably would be some reduction in the consumption of energy per person. That trend is offset in total energy requirements by the increase in the number of people.

Household formation

Household formation, which is a factor in space heating and in a number of other energy requirements, is expected to increase somewhat more rapidly in relation to population than it did from 1960 to 1975. This result follows because of the smaller average size of households. However, conservation measures and smaller average living space per household will limit any resulting increase in household energy requirements. The higher proportion of households in "multi-unit" dwellings (apartments and condominiums) will also tend to reduce space heating (and cooling) requirements.

The lower rates of growth in energy demand which result from population trends is reinforced by the general saturation of the demand for many kinds of goods and services (for example, the number of cars or appliances per household, the number of schools, universities and shopping centres). New housing and commercial and service centres also will be built with greater attention to energy efficiency.

TABLE 4-1

Indicators of Economic, Social and Energy Change, 1975 to 2025

	1975	2000	2025	Rates of Change 1975-2000	2000-2025	1975-2025	1960-1975
				(per cent/year)			
Population (millions)	22.8	30	33	1.2	0.5	0.7	1.6
Gross national product (in billions of 1975$)	161	375	560	3.4	1.6	2.5	5.0
Personal disposable income (in billions of 1975$)	108	250	375	3.4	1.7	2.6	5.3
GNP/capita (1975$)	7061	12500	16970	2.3	1.1	1.7	3.2
Personal disposable income/capita (in 1975$)	4737	8400	11364	2.3	1.1	1.7	3.6
Primary energy[1] (quads)	8	16	20	2.8	0.9	1.9	5.3
Secondary energy[1] (quads)	5.5	10	12.5	2.4	0.9	1.7	5.3
Secondary energy/capita (1975 = 100)	100	138	157	1.3	0.5	0.9	2.7
Primary energy/GNP[2] (1975 = 100)	100	86	72	-0.6	-0.7	-0.7	0.4
GNP/primary energy (1975 = 100)	100	116	139	0.6	0.8	0.7	-0.25

1 Secondary energy is the amount of energy available to the final consumer; primary energy is secondary energy plus conversion losses and waste and the energy used by the energy supply industries themselves.

2 The lower rate of increase in primary energy than in GNP is used as an indicator of a general increase in efficiency in energy use.

Participation rates

The level of gross national product is affected by the proportion of the population which is in the labour force (the "participation rate"), as well as the productivity of the individual worker. The participation rate has been increasing in recent years, particularly as more women become employed. That trend is expected to continue for a time but is likely to be offset, or more than offset, in later years by changes in lifestyles. Preference might well be shown for more leisure time in one form or another (a shorter working week or shorter working year, more months or years away from work, different combinations for learning and work, earlier retirement, and so on). The net effect of these trends, for purposes of this study, is to leave essentially unchanged the present relationship of population, labour force and gross national product. Productivity increases are expected to continue at just over 2 per cent a year.

Income redistribution

The level of gross national product can also be affected in complex ways by the distribution of income. Three main considerations affect that relationship.

First is the distribution of income among persons and families. A greater proportion of income to low income recipients is expected to take place. This tends to increase consumption rather than saving and, hence, to reduce somewhat, out of any given level of income, the funds available for investment.

Secondly, there are questions of regional income distribution. Some shift in incomes toward the western provinces seems inevitable, but later economic opportunities in central and eastern Canada (including those associated with energy) might partially offset that trend. The general income effect, both short and long-term, is considered to support relatively high economic performance in all regions.

The third income distributional effect relates to economic sectors (labour, business organizations, landowners, governments, etc.). The direction of change in recent years has been toward a higher proportion of labour income and government income. These tend, in the first instance, to lower business saving and the cash flow of business to capital investment. As the government share of income increases, an important consideration is whether that income is used for current expenditures (including transfers back to people in income-maintenance schemes), or whether it is used for capital investment including, for example, the financing of energy projects. In general, the long-term future distribution of income among economic sectors might make more difficult the high levels of saving which are deemed to be necessary, and to put

a larger proportion of the saving at the disposition of persons and governments rather than business organizations.

In total, a relatively high level of saving is expected to be forthcoming to finance, along with further inflows of funds from abroad, the investment projects. The proportionate substantial changes in the distribution of funds and the nature of the investment projects will require changes in the financial intermediation services that bring together available funds and capital projects.

Satisfactory economic performance

The rates of growth shown in Table 4-1 are the lowest which, by this assessment, are consistent with satisfactory economic performance, from now to the year 2000, and from 2000 to 2025. "Satisfactory" economic performance in this context means that work is available for those who want it; annual productivity increases are not lower than 2 per cent, and the level of real income and its distribution generally contribute to social harmony and personal well-being. "Satisfactory economic performance" contrasts with the situation of the past 2 or 3 years when the lower growth in energy consumption in Canada and abroad can be associated, in large part, with failure to achieve "satisfactory" economic performance.

Some analysts suggest that even lower rates of economic growth, and greater substitution away from oil and other conventional energy resources, are consistent with satisfactory performance. The lower growth would result from greater changes in individual and social aspirations. In that case, either the energy supply requirements would be voluntarily reduced further, or the lower growth rates would result from an inability to provide, under satisfactory conditions, a greater energy supply. However, on the other hand, higher rates of economic growth than those shown in Table 4-1 could occur if Canadians adopt more aggressive industrial policies, based in part on a potential international comparative advantage in energy resources beyond 1990. A significant part of that comparative advantage might show up in increased opportunities for the export (and import displacement) of energy-intensive goods. This relatively favourable energy position might increase the rate of growth in the use of energy by possibly another one half of one per cent above that allowed in the estimates used in this chapter. Moreover, structural changes to increase efficiency typically benefit from accelerated replacement of existing plant and equipment. This faster write-off entails higher costs and a need for greater resiliency, both of which are supported by stronger growth trends. To achieve and sustain higher rate of economic growth would require even greater energy efficiencies and substitutions away from oil.

The reduced rates of increase in real incomes per capita, especially notable after 2000, reflect the impact of structural changes in the economy and personal choices for more leisure time and fewer hours of work or years of work during the working life. The lower growth rates here depicted are not the consequences of poor economic performance. However, failure to carry out the necessary reductions and re-ordering of energy demand could result in unsatisfactory economic performance and lower levels of real income.

To some significant degree, either unsatisfactory economic performance or much stronger economic performance can become a self-fulfilling prophecy. The activities of individuals, as well as industrial and economic policies, are coloured by those expectations. These, in turn, will tend to produce either the strong or the poor economic performance. This report recognizes many potential opportunities for vigorous economic action.

A fundamental question regarding adjustments is whether they will occur by free choice and fairly automatically in response to higher energy prices, and whether price differentials will induce the necessary substitution of other energy resources for oil. A further question is whether Canada will gain a competitive advantage among countries of the world as a result of well managed, more adequate supplies of energy and smaller increases in prices than in most other countries. Such an advantage would encourage more rapid rates of industrial growth and, hence, of energy consumption by industry.

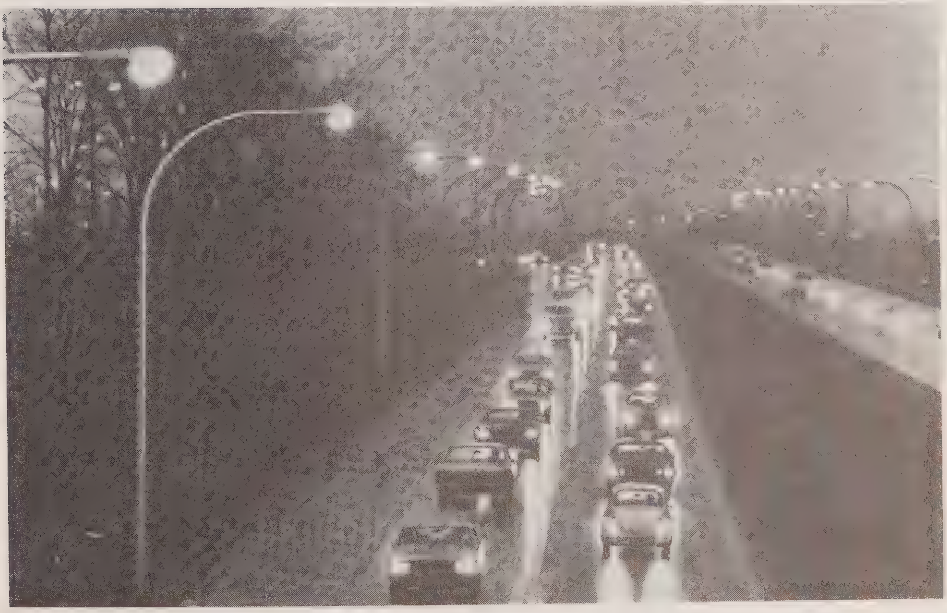
Any attempt to switch from capital-intensive production to more labour-intensive methods is likely to be generally inappropriate. In the absence of large-scale immigration, labour is likely to be in short supply in the future and satisfactory increases in real income per capita will require, as it has done in the past, a high ratio of capital to labour. A basic requirement is to ensure that additions to capital and new processes of production are as efficient as possible, in respect of their use of energy and of all factors of production.

Conservation, efficiency and structural change

Many of the changes in energy demand will occur because of economic and social changes unrelated to the transformation of the energy system. Others will result directly from the very much less favourable energy situation. It is these energy-driven demand changes which are significant to this study. The more severe the energy constraints become, the greater will economic and social activity be determined by the energy situation. The objective of the adjustment program, particularly over the next 25 years, is to avoid a high degree of energy determinism. Among the principal instruments of that adjustment process are energy

conservation, increased efficiency in the use of energy and structural changes in the economy and in personal lifestyles. These are, for the most part, long-term processes. The conservation and efficiency measures will act principally upon existing types of activity (for example, present housing stock, current patterns of automobile use, current methods of industrial production). Their main impact will be felt over the next 25 years.

Once the principal conservation and efficiency measures are in place, further moderations to demand and the substitution measures will come from underlying structural changes in the economy and changes in lifestyles. These will include, for example, new designs of dwelling units, transportation systems, urban design, and personal habits of work, leisure, travel and communication. Clearly perceived objectives, targets, direction and processes of change are needed now if the structural and lifestyle changes are to have a substantial effect even by the turn of the century. Thus, although major structural and lifestyle changes will begin now, and some already are underway, their principal impact will be felt after the year 2000.



The heritage of abundant, low-cost energy.
(National Film Board Photothèque)

The changes in the use of energy which were given in Table 4-1 indicate that the above increases in energy efficiency and conservation might reduce energy demand by nearly 20 per cent by the year 2000 from what it otherwise would be, and reduce it a further 60 per cent by 2025. Some analysts would put the technical possibilities of reductions much higher, particularly in response to higher energy prices. Other estimates show more moderate reductions, or larger offsets, as a result of higher rates of economic growth or the larger increases in the energy required to produce energy -- i.e. the energy used in the production and transformation of energy from more remote and difficult sites. Precise orders of magnitude are neither possible nor essential. Whatever the variations, the essential point is that sizeable opportunities undoubtedly exist to reduce energy demand through conservation and efficiency efforts and by structural changes in patterns of demand. At the same time, however, tremendous difficulties of adjustment will occur whatever programs are put in place to so moderate demand.

Other details on conservation programs are given later in this chapter.

Role of energy prices

Attempts to forecast actual price relationships for energy and the responses to them over so long a future are likely to be unproductive. In Chapter 9, some features of the price relationships and of the processes of price adjustment are outlined. In brief, price increase, price differentials and pricing policies are regarded as the most important single factor in the achievement of satisfactory adjustments. However, price changes alone are unlikely to bring about all of the complex processes of adjustments and do so with the appropriate timing to avoid major stresses. Energy prices already are largely "administered" to serve a variety of purposes other than the perceived requirements of long-term energy supply-demand balances. Other adjustment levers, including a variety of incentives and disincentives, will be required to complement price changes and to act in advance of clear price signals. The incentives, for example, might include accelerated depreciations, differential discount rates, favourable tax and mortgage provisions and changes in institutions and regulations to encourage re-allocations. The disincentives might range from penalizing tax provision, differentials in licensing and regulatory provisions to discourage inefficiencies, direct allocation and controls, or outright prohibition. The implementation of these adjustment levers, with a minimum of stress, will not be easy. It will require a consensus on objectives and explicit agreements among energy suppliers, energy users, the federal and provincial governments and others concerning energy demand and supply objectives and targets and how they might be

staged in through time. A combination of policy instruments in the government and private sectors will then be necessary to try to achieve the objectives and targets.

Productivity improvement

The increase in energy efficiency can also be viewed as an essential component of productivity improvement throughout the economy. Productivity gains underwrite further increases in personal incomes which continue to have a high priority for most Canadians. Productivity gains also support the provision of more social services, greater leisure time and greater personal choice. Higher energy efficiency, therefore, becomes part of the essential driving force for improved overall economic productivity which, in some instances, will require an increase in energy use. Energy-intensive production should then be made as energy-efficient as possible.

Imperative of increased energy efficiency

The rate of increase in both primary and secondary energy consumption, as shown in Table 4-1, is lower than the rate of increase in GNP. As a result, the ratio of energy to GNP declines appreciably (and its converse, GNP per unit of energy increases). These are most critical relationships. They are a rough measure of the increase in energy efficiency in future years.

An essential objective of a national energy program is that future increases in output and in incomes be achieved by ever-increasing efficiency in the use of energy.

The decline in primary energy/GNP is shown in Table 4-1 as an index in which 1975 is 100. By the year 2000, the ratio has dropped to 0.80 and by 2025, to 0.72. Such increases in energy efficiency are regarded as possible but extremely difficult. Any substantial degree of failure would jeopardize satisfactory energy adjustments. The achievement of increases in energy efficiency of those magnitudes represents a most ambitious energy policy, one that calls for a full national effort by all Canadians. It might be noted in Figure 4-2 that the ratio of the increase in energy used to increases in GNP remained almost constant throughout the past 25 years. Thus, no significant increase in energy efficiency in the aggregate has been achieved for a quarter of a century. Two earlier periods did demonstrate significant increases in energy efficiency -- the depression years of the 1930s and the war years of the 1940s -- not very auspicious illustrations.

The increases in energy efficiency between now and 2000 and again between 2000 and 2025 are required to match or exceed,

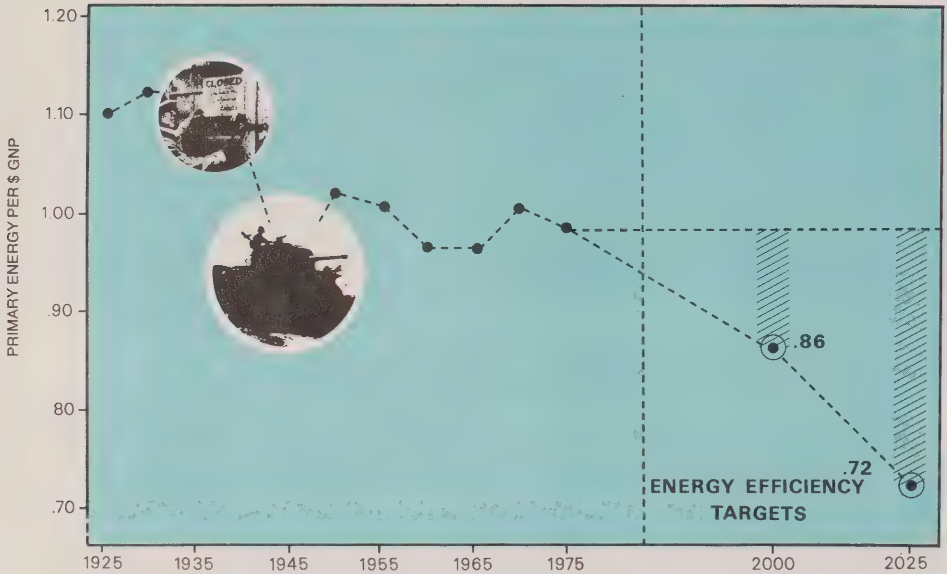


Figure 4-2. Ratio of primary energy use to constant $ GNP, 1925-1975, 2000, 2025.

continuously over a 50-year span, the best performances achieved only for much shorter periods in the past. Moreover, the increases in energy efficiency in the future are to take place without a major depression and without controls such as those imposed in war-time. In other words, the increases in energy efficiency would represent an unprecedented transformation and an unprecedented dedication by Canadians.

Changing patterns of energy demand

In addition to the general increase in energy efficiency, referred to above, satisfactory energy balances will involve significant changes in the shares of the various uses of energy and of the energy resources to serve those uses.

Some features of the change in patterns of demand which require particular attention include:

- changes among principal end-uses;
- changes in the energy resources which meet the demands; and
- provincial and regional demand patterns.

Principal end-uses

Particularly significant in efforts for energy efficiency and the substitution of other forms of energy for oil are space heating demands (about 30 per cent of energy use), and "mobile energy" for transportation (about 25 per cent of energy use).

Figure 4-3 shows that patterns of energy demand change toward greater relative emphasis on industrial use and a smaller share of energy for residential use. That change occurs primarily because the lower rates of population growth, the general aging of the population, smaller family (or household) size which results in smaller average household space, and the use of more multiple-unit dwellings (condominiums and apartments). Opportunities for greater energy conservation and increased efficiency might also have a greater impact on residential energy use and on space heating more generally.

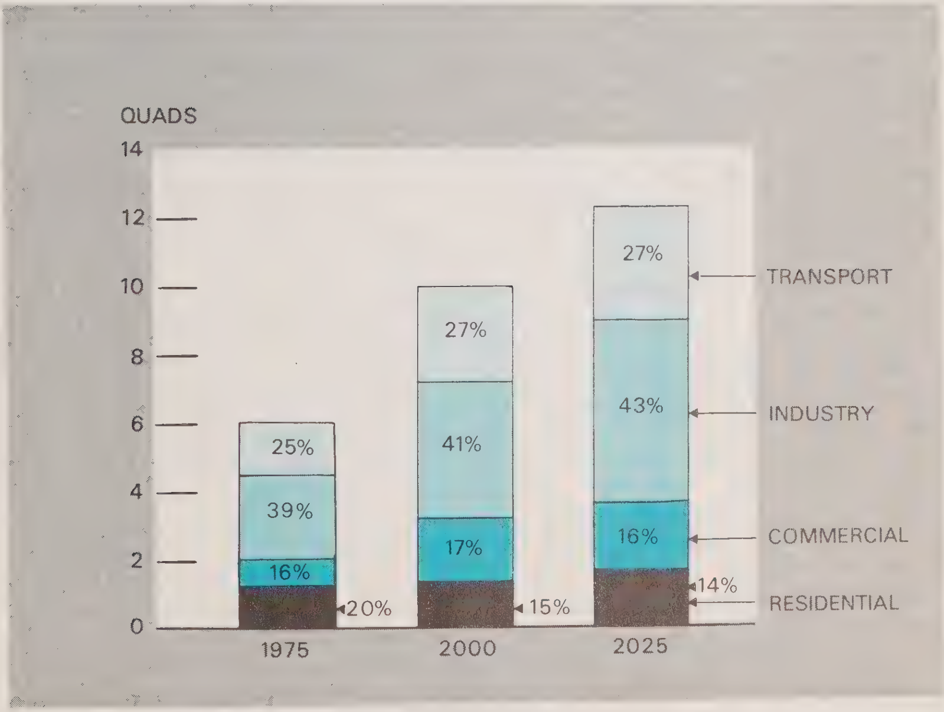


Figure 4-3. Energy demand by principal uses, 1975, 2000, 2025.

The shares of the transportation and commercial sectors do not change appreciably but in both instances that represents a significant application of greater efficiency in energy use and of structural changes in those sectors. Over the past 15 years, the commercial sector has been the most rapidly growing energy user. The constraint of its further, relative growth is, therefore, noteworthy. Energy requirements for transportation also have been growing rapidly. However, substantial increases in energy efficiency, particularly in the mileage performance of automobiles, the size of automobiles and lower speed limits, will have an immediate effect on energy used in transportation. In the longer run, even greater changes in transportation modes and efficiency are needed, particularly to hold down the expansion of the use of oil products in transportation. Thus, the moderate rate of increase in the share of transportation in total energy use results from very substantial efforts to prevent that share from increasing much more. Even more successful measures to increase transportation efficiency might hold the share constant, or reduce it slightly.

The resulting increase in industrial use, of slightly more than 3 per cent a year, is well below historical rates. A significant factor in the increase in industrial use of energy resources is allowance for expansion in non-energy uses such as petrochemical feedstocks and fertilizers. Initially, those industries will continue to rely almost entirely upon oil and natural gas for their feedstock requirements. Because the careful husbanding of oil is critical to Canada's energy future, some shift in non-energy industrial use to natural gas, coal and wood is to be encouraged. Technological innovation and economic considerations will mainly determine the extent to which such a shift can be made. In total, over the longer term, about one-half of the industrial use of oil might be switched to other forms of energy.

The energy requirements of the energy supply industries (the energy required to produce and deliver energy) is not included in Figure 4-3. Substantially larger amounts of energy almost certainly will be used by the energy industries as more remote and more difficult energy resources are brought into production. A barrel of oil from the oil sands requires much more energy for its production than does a barrel of oil from a conventional oil well. Similarly, natural gas produced and delivered from the Mackenzie Delta will require the input of far more energy than from a gas field in Alberta. In such instances, the <u>net</u> energy gain, therefore, is very much less than it was from former locations. Some account is taken of these additional supply energy requirements in Chapter 5, but it is recognized that much greater allowance perhaps should be made for the energy required to bring energy to the final user. However, there also are some offsets which might not be fully assessed. These include particularly greater use of waste heat, byproduct energy and other small,

local supplies. Considerable innovative efforts are warranted to ensure that the energy needs of the energy industries are efficiently met, and that, where practical, those energy requirements are met by resources other than oil and natural gas.

Even with the constrained growth in the use of energy by all of the principal sectors, a disturbing trend is developing. The industrial and transportation sectors, which are increasing in relative terms, are particularly heavy users of oil. Together, in 1975, those two sectors accounted for about 70 per cent of all of the oil used and, especially within transportation, the substitution of other fuels for oil products will be extremely difficult. Substitutions within the smaller oil users -- the household and commercial sectors -- are easier to make, but will have less overall impact on total oil requirements. Thus, the changing patterns of demand do not, in the first instance, support the objective of substituting other energy resources for oil. Efforts to achieve those substitutions will have to be particularly great and deliberately planned from this time forward.

Changes in resource requirements

Figure 4-4 and Table 4-2 indicate current patterns of energy demand by type of energy use, and the proportion of each form of energy for each use.

These patterns of energy use give some indication of how the changes in end-uses, shown in Figure 4-3, might be expected to affect the demand for the energy resources. The declining share of residential space heating requirements will affect 19 per cent of oil. At the same time, the scope for substituting other forms of energy for oil in residential energy use is shown by the fact (Figure 4-4) that over one-half of the residential energy is supplied by oil. Thus, a combination of a lower share of residential use of energy and the susbstitution of other forms of energy for oil in space heating requirements could significantly reduce the total demand for oil.

The commercial sector does not show a declining share of total energy use. Although it accounts for only 11 per cent of total oil requirements, that use of oil can be significantly reduced since much of it is for space heating.

Oil used for space heating is regarded as most amenable to replacement by other energy resources but, as pointed out in the energy balances of Chapter 6, the more difficult substitutions in transportation and industrial use also will have to be tackled.

The transportation sector is expected to retain or somewhat increase its present share in total energy use; it is almost entirely dependent on oil, and accounts for over 40 per cent of all oil demand. Thus, transportation is a key sector for programs

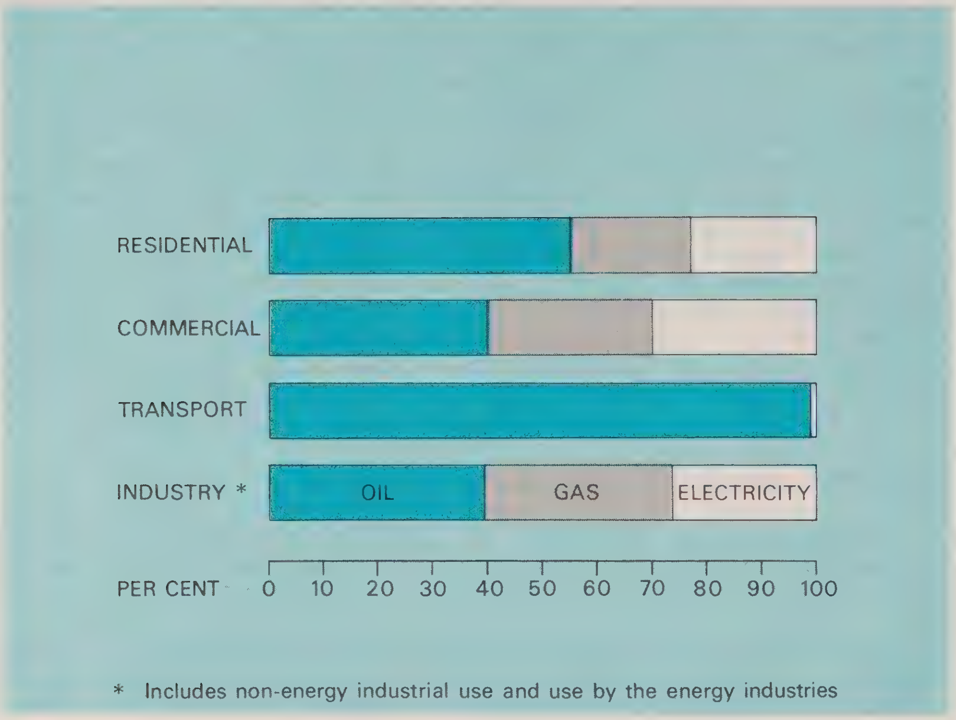


Figure 4-4. Energy demand by energy resources, 1975.

to increase efficiency and to alter patterns of energy use away from oil. It also is the most difficult in which to effect substitutions away from oil.

Because the industrial use of energy is an increasing share of the total, the industrial sector, which now uses 28 per cent of the oil, will become an area of particular concern in terms of total energy requirements and the substitution of other forms of energy for oil.

Demand targets

The above outline of patterns of energy demand in 1975, and the changing shares which each of the principal demand sectors might represent in 2000 and 2025, can be considered in terms of the three principal demand targets.

- Ensure that the new energy systems are appropriate to new economic and social opportunities in Canada.

TABLE 4-2

Energy Resources by End-uses:
Sources of Energy Distributed
by End-use Sectors, 1975

To	Oil	Natural gas (per cent)	Electricity
Residential	19	23	24
Commercial	11	19	25
Transportation	42	-	-
Industry[1]	28	58	51
	100	100	100
	(1 767 000 b/d)	(1 450 billion cu.ft./yr.)	(266 billion kWh)

[1] Includes here non-energy industrial use, energy used by the energy industries and for electricity generation.

- Reduce, from now to the year 2000, energy demand to one-half of its historical rate of 5.3 per cent and reduce the rate of increase in demand by at least one half again from 2000 to 2025. These demand reductions would be accomplished by means of conservation, increased efficiency and longer term structural changes.

- Reduce further the demand for oil by substituting other energy resources for oil so that the share of oil in total primary energy requirements is reduced from its present 45 per cent to 30 per cent by 2000 and 25 per cent by 2025.

If the modified increases in demand outlined in target 2 above occurred without substitutions away from oil, the demand for oil would be as shown in Table 4-3.

TABLE 4-3

Illustration of the Increase
in the Demand for Oil before Substitution

	1975	2000	2025
	(million barrels per year)		
Residential	122	150	250
Commercial	70	125	150
Transportation	269	500	550
Industrial	179	275	350
Total	640	1 050	1 300

It can be seen in Table 4-3 that, if no substitution takes place, the demand for oil might increase by over 60 per cent by the year 2000 and double by 2025. In looking at ways to reduce the increase in oil, therefore, each of the sectors of demand can be considered separately. However, even more appropriately, energy demand for all sectors can be considered within certain broad, functional categories as follows:

- low-temperature heat (mostly space and water heating, also industrial drying processes);

- high-temperature heat (mostly for industrial processes);

- stationary mechanical drive (mostly industrial machinery);

- mobile mechancial drive (transportation); and

- lighting and electric circuitry for business and household appliances, refrigeration and air-conditioning.

Significant technical possibilities of replacing oil by other forms of energy, in terms of the above functional characteristics, are illustrated in Figure 4-5.

A major difficulty to any substitution of other energy resources for oil is that oil is a preferred fuel for very good reasons. It is low-cost relative to alternatives, a concentrated, fairly clean, easily handled and easily stored fuel. Efficient, widespread production, transportation and marketing systems are in place. Oil also is versatile in its end-uses so that complementary demands for various oil fractions can be established. This impressive range of advantages to the use of oil are extremely difficult for any substitute to meet. Only necessity or a clear price advantage will induce significant substitutions.

The above functional approach to reducing energy demand and to the substitution of other forms of energy for oil would result in five major, national programs of adjustment. The programs are:

- space heating program (space and water heating and cooling);

- transportation energy program (the use of "mobile" energy);

- industrial energy program (the use of "process and mechanical-drive" energy; the availability of byproduct energy);

- consumer products energy program (packaging, standards, design, durability and recycling); and

- community design energy program (all energy forms in an integrated "community enterprise" approach).

CATEGORIES OF END-USES	PRESENT DOMINANT ENERGY SOURCES	SUBSTITUTIONS* FOR OIL
LOW-GRADE HEAT (up to 100°C.) -Space and water heating -Space and water cooling -Industrial drying	Oil Natural gas Electricity from -hydraulic -coal -nuclear -oil -natural gas	Electricity -resistance -heat pump Natural gas Solar -heat storage -absorption-refrigeration District heating systems Dedicated thermal plant which also co-generates Waste heat from power generation Waste heat from industrial processes Coal Geothermal Biomass (wood) -direct combustion -via SNG
HIGH-GRADE HEAT (over 100°C.) -Industrial process steam -Thermal-electric generating -Industrial direct heat (e.g. metallurgical) -Appliances - thermal (e.g. stoves, dryers)	Oil Coal Natural gas Electricity from -hydraulic -coal -nuclear -oil -natural gas	Coal - direct combustion - via SNG Nuclear Natural gas Biomass (wood) Electricity (exclude oil and natural gas generation)
LIGHTING -All sectors	Electricity from -hydraulic -coal -nuclear -oil -natural gas	Electricity from conventional sources (exclude oil and natural gas) and from new generating forms

Figure 4-5. Possible end-use substitution for oil.

CATEGORIES OF END-USES	PRESENT DOMINANT ENERGY SOURCES	SUBSTITUTIONS* FOR OIL
STATIONARY MECHANICAL DRIVE Industrial, manufacturing Appliances - electromechanical (e.g. vacuum cleaner) Remote electricity-generating	Electricity from -hydraulic -coal -nuclear -oil -natural gas Oil	Electricity, as above Chemical fuels, e.g. coal via SNG Natural gas Wind power
MOBILE MECHANICAL DRIVE		
Ground		
-automobiles	Oil	Synthetic fuels from coal and biomass
-trucks	Oil	Electric drive, hydrogen
-industrial mobile equipment (e g. draglines)	Oil	Electric drive, hydrogen
-rail	Oil	Electric drive, hydrogen
-pipelines	Oil and natural gas	Electric drive
Aircraft	Oil	Synthetic fuels, hydrogen
Marine		
-ships	Oil	Synthetic fuels, hydrogen, nuclear

* Electricity generation is assumed to be generated primarily from hydraulic, nuclear, coal, some biomass, co-generation and wind but not oil.

Figure 4-5. (cont'd). Possible end-use substitution for oil.

These major programs are outlined later in this chapter in terms of the two objectives of reducing the rate of growth in energy demand and of substituting other forms of energy for oil. The impacts of these changes are examined in Chapter 6 in respect of achieving satisfactory balances of energy demand and supply and recommendations concerning them are given in Chapter 13. In all respects, the programs involve energy conservation, increased efficiency within existing patterns of use, and structural and lifestyle changes for longer term adjustments. Before looking at each of the programs, some of the characteristics of provincial energy use common to all programs might be noted and some general conservation and efficiency measures recorded.

Provincial and regional patterns of energy demand[1]

Figure 4-6 illustrates the regional patterns of energy demand in terms of the resources used. The significance of this pattern of use is two-fold. On a national scale, the largest impact from changing patterns of demand can be expected to come from changes in Ontario and Quebec which, together, account for nearly 60 per cent of Canada's energy consumption. However, to replace imported oil, changes in patterns of use and the substitution of alternative energy supply for oil are concentrated first in the Atlantic provinces and Quebec which together account for virtually all the imported oil, and for nearly 45 per cent of all oil used in Canada. The Sarnia-Montreal pipeline is one step in reducing the dependency of eastern Canada on imported oil. However, if other great efforts are not made, imported oil might, within a few years, also be required in Ontario and, possibly, British Columbia.

Substituting other energy resources for oil and increasing efficiency in energy use <u>anywhere in Canada</u> can, within a national energy program, alleviate serious difficulties across the country. As more coal is used in the western provinces, more oil or natural gas might be available in central and eastern Canada, entailing additional pipelines. Forms of substitution will differ across Canada and will not always be a single, straight switch of some other resource (natural gas, electricity, coal, biomass, etc.) for oil. To reduce the demand for oil in Quebec and the Atlantic provinces, a first strategy is to make natural gas and more electricity available. Co-generation of electricity and heat, local use of peat and forest biomass, more coal in Nova Scotia can all contribute to a lower demand for oil.

The provincial patterns of resource substitution are dealt with further in Chapter 7. Of significance here is that <u>patterns of demand as well as of supply must change if sustainable balances</u>

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1 See also Chapter 7.

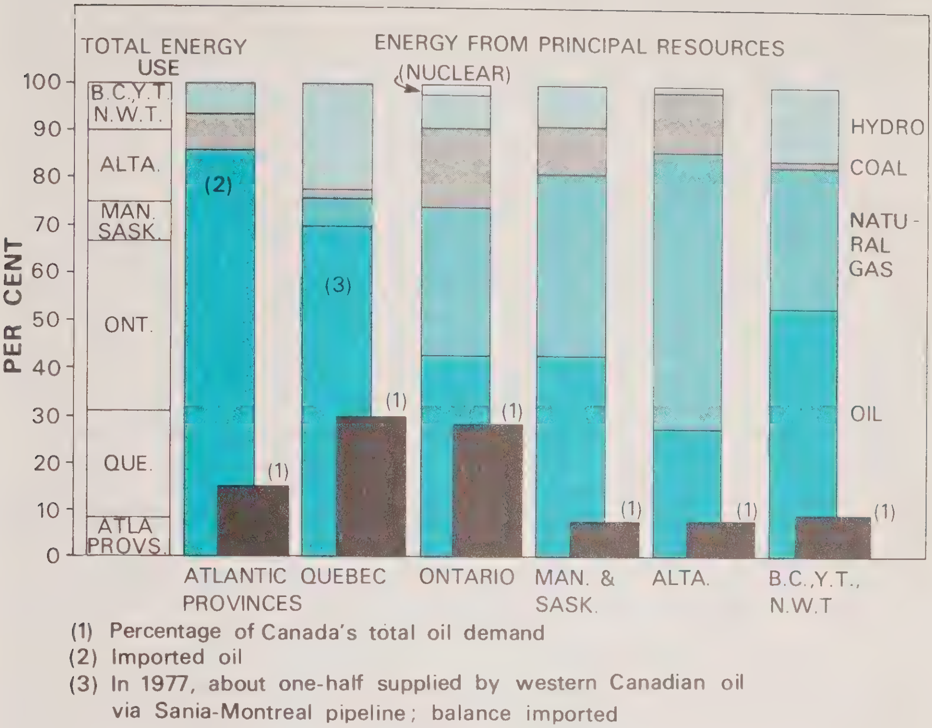

Figure 4-6. Percentage distribution of total regional energy use and sources.

are to be achieved. Each province separately can seek to achieve through time changing patterns of demand which can rely in some substantial part on resources available in that province or region. At the same time, coordination of provincial energy policies, in terms of both demand and supply, is of critical importance to provincial well-being. The implications of coordinated energy policies can be assessed in terms of achieving higher employment and improved industrial and economic performance in each province. The merits of a national approach to energy as a keystone to industrial policy and to provincial and regional development are evident. A national energy program can become a functional, national link for mutual benefit much as the railroad did one hundred years ago.

Conservation and energy efficiency

Conservation and increased efficiency measures are thought of mainly in terms of their contribution to the overall reduction in energy demand. However, these measures are also an integral part

of achieving a different pattern of energy balances based upon the energy which will be available beyond 1990. In this context, conservation and efficiency should be integrated with the substitution objective. In some circumstances, a smaller saving in total energy will be justified in order to obtain a larger saving of oil. Less technically efficient forms (for example, forest biomass) might be used to that end.

The economic gains from conservation and increased efficiency can be great. A reduction in the use of energy by one or two quads by 2000, for example, renders unnecessary the building of many large energy supply facilities such as nuclear stations or oil sands plants, with all of the attendant savings in plant, equipment, supplies, labour and management inputs, and financing. However, the full economic and social impacts of conservation programs are not known. Conservation projects themselves constitute substantial economic activity which requires new institutional and managerial arrangements, financing, materials, equipment and manpower. Frequently, conservation programs are assessed only in terms of their apparent, direct energy "saving", not in terms of their impact on total economic efficiency or the optimum allocation of resources. In other words, conservation programs are not a "free good". There are substantial costs as well as substantial benefits.

Large-scale conservation programs can be likened to a new energy resource, and are not unlike the creation of a new energy supply industry. Assessments are needed of the conservation "resource" potential and the rate of its producibility. There is a "learning curve" of experience, design, management and organization, and for start-ups and "running in" periods. These qualifications do not detract from the substantial benefits to be gained from well conceived and well conducted programs for conservation and increased efficiency.

Conservation initiatives

Energy conservation efforts have increased significantly in the past two or three years, and more systematic approaches to specific conservation objectives are beginning to emerge. Much of the initiative for conservation programs, and much of their success or failure, rests with the federal and provincial governments. The federal government is taking a number of important initiatives and is in a position to coordinate much of the conservation approach into a national effort. The federal government programs are organized principally within the Office of Energy Conservation in Energy, Mines and Resources, Canada. These programs are outlined in more detail elsewhere.[1]

1 "Energy Conservation in Canada: Programs and Perspectives"; Department of Energy, Mines and Resources, Ottawa; EP 77-7.

However, energy conservation and increased efficiency is ultimately the responsibility of individual Canadians. Many of the programs are geared to the individual -- for example, reducing gasoline use and reducing home heating requirements. Even improving commercial and industrial plant efficiency is carried out by personal effort.

In brief, the main strategies identified by the federal government are:

- energy pricing for conservation;

- space and water heating and cooling;

- transportation;

- industrial use; and

- consumer products.

Energy pricing for conservation

The anticipated doubling of the real price of oil by about the year 2000, and the sharp increases in prices of other energy resources, will provide the major incentive for energy conservation and for increased efficiency. No attempt is made here to set down precise price elasticities -- by how much energy demand will be reduced in relation to increases in energy prices -- nor to estimate the partial offsets from rising real incomes. A doubling of energy prices and the possibility of energy shortages unquestionably will induce substantial conservation efforts. To encourage energy conservation and greater efficiency, the full effects of increasing prices should be permitted to impact consumers. The federal government has established a policy of moving oil prices in Canada towards world levels. Prices of other forms of energy will inevitably increase. The pricing objective for conservation is to price energy at replacement cost and to avoid price distortions that encourage higher energy consumption. Thus, a conflict arises between higher prices for conservation and a moderation of price impacts to prevent hardship and inequity. If the programs to alleviate hardship and achieve equity are incorporated into energy prices by subsidies or other means, their effect will reduce the conservation impact. Other forms of income maintenance are preferable. The hardship to low-income recipients and the unequal impact of higher energy prices can be dealt with by income protection and income distribution programs.

The competitive position of Canadian industry in world markets should not be materially worsened by higher energy prices partly because energy prices are a relatively small cost of production costs (though the indirect cost effects through higher wages and

One of many ways to reduce energy waste.

higher material and equipment costs greatly increase the impact). More important, other industrial countries will be experiencing energy price increases at least as high as those in Canada. Moreover, the conservation and efficiency measures are designed to reduce the impact of higher energy prices and to increase overall productive efficiency.

Over the next few years, conservation incentives will tend to be reduced if the real price of energy does not increase appreciably. Conservation and efficiency measures, however, should not be delayed until propelled again, probably under crisis conditions, by sharply rising energy prices. Moreover, if energy prices increase gradually, the impact on conservation and efficiency will be blunted. Other incentives, in addition to price increases, are therefore called for. These include taxes, regulations, building standards, and similar devices. It is essential that the full range of conservation and efficiency measures be treated comprehensively within the programs of the federal government, the provinces, industry and the Canadian public as part of the more general objective of achieving satisfactory energy balances.

The conservation and efficiency measures, therefore, become part of the broader question of the effective use of energy in support of satisfactory economic performance and enhanced social well-being. This effective use is also linked closely with the substitution objective. The combination of these various demand elements are illustrated below in terms of the five national programs.

Five national programs for transformation of end-uses

Five national programs are recommended to bring about necessary structural changes so that the new energy balances will be based on the energy we can have in our future, not what we are accustomed to use.

1. National space heating program (low-temperature heat)

Space heating uses nearly 70 per cent of the total energy in residential, commercial and industrial buildings. The remainder is for lighting, cooling and appliances. Overall, space heating accounts for about 30 per cent of total Canadian energy use, and is a significant user of oil.

One objective is to reduce by half the energy requirements for space heating. This would be accomplished by large-scale insulation and other "retrofit" programs and by the use of energy efficient designs for new households, commercial and industrial buildings, government buildings, and so on. Byproduct heat sources also will be called more into use, as will improved operations and maintenance, and the increased use of automatic control devices. Space cooling and water heating and cooling are related matters for investigation. Heat storage and transfer systems and improved efficiency in heating and cooling equipment are important features of these programs.

District heating systems would be encouraged to make use of the vast heat potential of thermal generating plants, urban centres and industrial complexes. Experimentation with biomass, the use of municipal waste, solar energy and "low-head" (small site) hydro resources also will be called for. Pilot and demonstration projects are required in different locations across Canada to evaluate various approaches to district heating and other heating-efficient systems. These modifications in space heating should also result in substantial reductions in the use of oil for space heating, toward the target of virtually moving oil out of space heating. This change in the use of oil products creates difficulties in the efficient operation of oil refineries. Refinery adjustments will tend to stretch out the time taken for substantial reduction in the use of oil in space heating. At the same time, however, the demand for other oil products will be undergoing considerable change -- for example, the demand for gasoline, diesel fuels and petrochemical feedstocks. Attention already is being directed to the refinery problem. Within the context of this report, as noted in Chapter 6, it becomes part of a consolidated energy supply program.

The space heating and cooling program encounters many institutional, organizational, financial and regulatory problems in part because of the diffuse nature of heating requirements and fuel supplies. Space heating is supplied principally by oil companies, gas and electric utilities, and fuels come under various regulations. Little or no institutional capability exists to modify space heating systems (for example, by the installation of heat storage), or to deliver different forms of energy (for example, solar heat, district heating systems, co-generation or byproduct industrial heat). Thus, the structural changes in space heating will require extensive institutional re-organization by governments (federal, provincial and municipal), government corporations and the private sector. In keeping with the other energy transformations, jurisdictional, institutional, financial, regulatory and management aspects of the national space heating and cooling program constitute a strategic issue area for much further investigation and direct action.

Critical to the success of a national space heating program is the identification of potential long-term structural changes, in all parts of the country, which can support the long-term demand objectives of satisfactory economic performance, moderation of the growth in energy demand, and substitution of indigenous energy resources for oil in the various regions of Canada. Substantial changes can be expected in the mix of energy resources which are used for space heating and in the way they are used. For example, dwelling units will be built to much higher standards of energy efficiency, probably to serve smaller households with less area per person. They will have individual and highly automated control systems to achieve energy

efficiencies. Heat storage and heat transfer systems will increase appreciably in use. In large urban centres, many dwelling units might be concentrated in or near multiple-unit buildings, not necessarily "high-rise", but in a position to use district or other centralized heating systems. Greater planning will go into location of dwelling units in relation to work and leisure activities and waste or byproduct sources of energy. Dwellings, industries and commercial centres will rely to a significant degree on passive solar heat and other entrapped and stored heat. Rural and remote areas and smaller urban centres might rely in large part upon local, dispersed energy sources such as solar, biomass, wind, "low-head" hydro, peat and industrial process and waste energy sources.

2. Transportation energy program ("mobile" mechanical drive)

About 25 per cent of Canada's energy budget goes to transport goods and people. This is based almost entirely on oil and accounts for over 40 per cent of Canada's oil consumption. Over one-half of this use of oil is by the automobile, mostly in and around cities. Thus, in terms not only of energy conservation but also in reducing the demand for oil, the transportation sector, like space heating, is a key point of focus. The two principal targets are: first, to ensure that the transportation sector does not increase, and preferably declines, as a share of total energy use, and, second, to reduce the use of oil products to about 75 per cent of total energy used in transportation rather than the near - 100 per cent which they now are.

During years of cheap and abundant oil little attention was paid to the efficient use of oil products in transportation. Methods which are being implemented or investigated to increase efficiency and to reduce the demand for oil include the following:

- Increase vehicle efficiency to achieve better miles per gallon performance. This can be done by better operating and maintenance practices, technological improvements to the engine, drive train and vehicle, and by decreased vehicle size and weight.

- Increase load factors by encouraging maximum loading and by better driving habits, including lower speeds.

- A shift to more energy efficient modes of transport -- from single passenger cars to multi-passenger cars, buses and trains, and greater use of public transit systems.

- Reduce demand for travel -- better urban planning, changing personal preferences.

- Greater rationalization of intermodal systems (rail, road, air and water) and improved vehicle utilization for urban and inter-urban freight haulage.

- Substitute communications for travel, thereby reducing personal mobility.

- Use other fuels than oil products -- methanol and other "synthetic liquids", hydrogen, and electricity.

Much of the jurisdiction regarding transportation rests with the provinces. Speed limits, urban designs, traffic and parking regulations, public transit, license fees and other matters are covered by provincial and municipal regulation. Federal government support, encouragement and coordination can greatly assist the provinces in ensuring that residents in each province benefit from the energy savings which can be realized in transportation. In all of these matters, as with space heating referred to above, substantial institutional and regulatory changes are required.

Federal government actions in support of the above objectives include:

- raise mandatory fleet fuel standards to 24 miles per gallon in 1980 and 33 mpg in 1985;

- a gasoline excise tax of 10¢ per gallon;

- a graduated excise tax on weight, applied to large cars;

- an excise tax on automobile air conditioners; and

- a fuel economy labelling program and publicity re car efficiencies.

Between now and the year 2000, a considerable improvement in conservation and efficiency can be made by measures such as the above and by fairly simple modifications to vehicle size, weight and performance. For example, 3 or 4 people travelling in a car pool greatly increase automobile efficiency, and could do so at a significant financial saving, both to the individual and the municipality. Car rentals instead of private ownership could effect further economies. In the longer term, more extensive changes are possible. These involve, for example, substantial urban re-design for transportation efficiencies, new technologies for public transit systems; the use of a small, electric or liquid fuel (not necessarily gasoline) "commuter" and "shopping" carts; greatly improved freight handling systems; greater rationalization of intermodal transport systems.

An important form of "transportation" is earth-moving for large construction projects (roads, buildings, etc.), for resource development (e.g. strip mining of coal and oil sands) and other "off-highway" uses (such as farm and factory). Opportunities undoubtedly exist to increase the efficiency with which these operations are performed and to substitute electricity or other forms of energy for oil products in those uses.

Electrification of the railroads is another means of substituting electricity for oil, although the actual reduction in the use of oil is not great. The construction of an additional oil sands plant, in effect, to meet rail transport needs might be a preferred solution, at least over the next 10 or 20 years. As with so many other aspects of the energy situation, Canada is unlikely to make independent decisions in matters of rail electrification. If the United States and other industrial countries which do not now have electrified rail systems go strongly into electrification, the motivation and the ability of Canada to electrify will be increased. However, an independent assessment of the Canadian situation might suggest reasons to develop our own capability to do so in advance of other countries.

Another increasing form of transportation is the movement of energy resources themselves. Substantial increases can be expected to take place in the rail, ship and pipeline transport of energy resources and in the transmission of high voltage electricity. It is essential that the technologies of energy transport be investigated with a view to increased efficiencies and the substitution of other forms of energy for oil. The electrification of pipeline pumping stations which now use oil is one possibility.

Problems of the refinery mix of oil products, as a result of the reduced demand for the high-value gasoline fractions, will be partly solved by the overall reduction in demand for <u>all</u> fractions so that the imbalance in the refinery mix will not be so serious as it might appear to be at first glance. A complementary reduction for the middle distillate fraction for heating was referred to above. Also, the increase in the industrial demand for high-value feedstocks, price increases for other oil fractions, and new refinery processes to alter the proportions of products will help to ease, and eventually overcome, the refinery mix problem.

The comprehensive and systematic approach to all phases of transportation, the need for considerable technological development, pilot projects and test runs, as well as the need for very close coordination of effort by the federal and provincial governments and by industry, leads to a recommendation that a <u>national transportation energy program</u> be established.

3. Industrial energy program (stationary mechanical drive; high-temperature process heat)

Four features of a national industrial energy program merit special attention. These are:

- increase substantially the efficiency with which energy is used by industry;

- substitute other forms of energy for oil;

- use the equipment, materials and service requirements of a greatly modified energy system as a major dynamic for industrial and regional development; and

- develop in Canada, around the new patterns of energy supply, an international comparative advantage in a range of industrial products.

The above features apply also in large measure to the commercial use of energy. In keeping with the other major energy programs, the industrial energy program offers a strong support to satisfactory economic performance and individual and community enhancement.

Industrial use accounts for 40 per cent of total energy demand. The potential for energy savings is high following years of cheap, abundant energy. Over the 50 years to 2025, an increase in industrial efficiency in the use of energy could yield substantial results -- an ultimate reduction of 50 per cent in energy used per unit of output might be a realistic goal. This includes an allowance or "credit" for the use or sale of byproduct heat or other forms of energy which have not been fully, or commercially, used in the past. Substantial quantities of such energy are available in industry. However, great difficulties arise concerning the organizational and institutional changes necessary to bring those forms of energy into full use.

An increasing share of energy is expected to go to industrial and commercial use. That trend emphasizes the need to substitute other forms of energy for oil in those sectors. In addition to the increased use of "byproduct" and "waste-produce" energy sources, noted above, greater use of electricity can take place. Greater use of natural gas, synthetic natural gas, other liquid fuels, peat and hydrogen also will likely be possible. Moreover, some industries, such as petrochemicals and fertilizers, use oil, natural gas, coal and wood as raw materials or "feedstocks". These non-energy uses of energy resources are expected to increase relative to industrial production as a whole. Similarly, the energy industries themselves, in the production, transportation and distribution of energy, are expected to use more energy per unit of delivered (or "secondary" energy). These

energy-intensive and feedstock uses of energy resources require particular examination to ensure that they are as energy-efficient as possible.

Energy conservation and efficiency measures for industry include:

- improved energy efficiency in existing and planned plants, including more energy efficient processes and equipment;

- maximum use of byproduct energy, for example in the co-generation of electricity and heat;

- the use of discarded materials for energy production;

- the recycling of materials to reduce the energy requirements of materials processing;

- the development of products that require less energy in their manufacture, packaging and use, and which have high durability and recycling capabilities; and

- more extensive flow of energy conservation information including the results of test projects; the use of energy audits.

Over the longer term new plant and equipment design, plant siting to take account of available energy sources, complementary and byproduct production are among the ways in which greater energy efficiency and overall industrial productivity might be increased. The substitution of other forms of energy for oil in industrial uses is a closely related objective. The target is to replace oil in at least one-half of its present industrial uses. Most of the incentives for increased energy efficiency and a reduced use of oil in industry rest with the industries. Industry committees or councils can undertake most of the initiatives.

An objective that might be accepted for example, by agriculture, forest products, chemicals and metal fabricating, is to achieve a high degree of energy self-reliance -- to produce for use or for sale as much byproduct energy as possible. As the costs of conventional forms of energy increase, these energy sources will become increasingly attractive. Experimental and pilot projects can do much to ensure that the alternatives are ready to come into use by demonstrating practical technologies, institutional arrangements, financial services, equipment requirements, economic viability and social acceptability. The deployment of successful experimental results can then follow broadly through the industry. The federal and provincial governments will be called upon to work closely with industry to ensure that the coordination of the activities and the successful results are widely applied.

If Canada takes advantage of its long-term comparative advantage in energy, there will be a tendency for energy-intensive processes of production to increase, thereby increasing the industrial use of energy. This will make the achievement of energy efficiency in industrial use all the more necessary.

4. Consumer products energy program

The objective for consumer products is to significantly improve energy efficiency in the products, in packaging and in disposal and re-use. This program will affect the components of residential energy use other than space and water heating, namely lighting and appliances. Greater energy efficiency built into the products is one important consideration, but product durability (life cycle cost) and the cost and ease of repair are also important. Greater interchangeability of standardized, modular parts and greater use of "one-stop" repair and maintenance centres are possibilities. These might, for example, employ new entrants to the labour force, handicapped persons working under skilled direction, possibly supplied by semi-retired persons.

Household appliances are estimated to use 6 to 8 per cent of the national energy budget. The manufacture and marketing of the products also offer scope for energy savings. In addition, the increase in public awareness of the need for energy conservation and increased efficiency, which can be demonstrated for consumer products, can do much to establish public participation in energy programs more generally. Consumer education and information programs can help to increase efficient use of consumer products. Efficiency standards, labelling, durability improvements, waste reductions in production and marketing, and consumer product testing laboratories are ways to achieve energy savings. A start has been made in some of these measures, but extension, intensification and integration of effort holds great potential. Re-use, re-design and re-cycling are part of a program of greater energy efficiency. As with the other national programs, the improvement of energy efficiency in consumer products confronts many institutional and regulatory constraints which will require concerted action to overcome.

5. Community design energy program (all energy systems in combination)

For greater efficiency in energy use, a community might be regarded as a single energy "enterprise". A thorough study of communities would bring together in a systematic, comprehensive way, the uses referred to above -- dwellings, transportation, industrial and commercial use -- to ensure that the most rational integration of energy supplies and use is achieved. The City of Toronto, for example, might be examined to see how, over the long term, energy efficiency could be substantially improved, and how other forms of energy could replace oil. Inter-community

links would be considered in much the same way. Important to this kind of consideration also are small communities, many of which are rural or frontier. Much greater integration of local energy resources (wind, solar, biomass, low-head hydro and similar resources) might be exploited.

It is anticipated that community energy evaluation programs would yield significant, additional efficiencies beyond those found for the individual components of energy demand. Thus, full-scale urban design investigations and pilot projects of urban energy rationalization are recommended. For example, multi-functional buildings can reduce idle space and time, and reduce transportation requirements; rationalized freight delivery systems can avoid duplication and underutilization; advanced and integrated urban transit systems are possible; the integrated use of byproduct and waste product energy can reduce dependency on conventional, non-renewable resources. The effective handling of space, time and travel are important elements of energy efficiency in the community.

Economic and social opportunity programs

The principal emphasis of this report of necessity must be on the extremely difficult problems which confront Canadians, in common with other people, in dealing with an unprecedented deterioration in the world energy situation. However, a systematic, long-term approach to meeting those problems, properly addressed, will also reveal many opportunities to institute imaginative, constructive programs for the economic and social betterment of Canadians. As the energy transitions proceed, economic and social structures will undergo transformations which can maintain or enhance the well-being of Canadians in all regions of the country, but under much different conditions than today.

These economic and social transformations spring from five main sources:

- activities associated with demand moderation and with changing patterns of demand (new housing designs, new transportation systems, urban re-design, energy-efficient industrial plant and equipment, community and other infrastructure requirements);

- activities associated with the systematic provision of enhanced and new energy supply capabilities (10 or more oil sand and heavy oil plants, new hydro and nuclear sites, new coal mines, transport systems, district heating and renewable resources, etc.);

- support industries and infrastructure (for example, iron and steel and machinery fabrication, electrical machinery and

equipment, motors, chemicals, wood products, repair and maintenance services);

- new industrial opportunities to take advantage of Canada's future comparative advantage in energy -- new export opportunities and import-replacement opportunities based on that energy advantage; included in those opportunities, in addition to energy-intensive manufactured products, will be capital equipment and production systems for energy (for example, CANDU, thorium and organic-cooled reactors, heavy oil recovery and processing equipment, pipeline technology and services, geological survey and evaluation services); and

- technological innovations and new management, financial, institutional and environmental systems designed to remove bottlenecks and to ensure that comprehensive and coordinated energy programs proceed in a well staged manner through time and that maximum advantage is taken of the "intellectual capital" associated with these developments.

Energy-related projects such as the above offer considerable scope for employment and capital investment opportunities, higher incomes, regional development policies and new international trade and financing initiatives. In terms of employment, for example, energy projects ranging from insulation programs to oil sands and nuclear projects, from local, byproduct energy projects to major land-use and community settlement programs, and from individual solar-heated homes to scientific research in untried energy technologies offer both a variety and magnitude of employment opportunities to strain our manpower capabilities. Carefully coordinated staging of projects, in all parts of Canada, will be essential if severe constraints, including an inability to finance and to man energy-related projects are to be avoided.

Opportunities exist to launch extensive training programs to meet the more highly skilled manpower requirements of many of the energy projects and the related industrial, infrastructure and community programs. If manpower assessment and training programs are not undertaken, the inadequacies of labour supply could impose serious constraints and create inefficiencies in the implementation of energy-related activities. Labour unions can have a significant role in these manpower programs. Substantial opportunities also would be lost for providing higher earnings for many members of the labour force, for providing local employment opportunities, and for introducing new and flexible employment programs.

These energy transformations and their support activities give rise to economic and social opportunity programs designed to take advantage of the changes. These programs are noted in the Recommended Programs of Chapter 13.

The changing society

Well before the year 2000 more extensive changes in lifestyles, communities and economic structures will begin to have a significant impact on energy demand, but their principal contribution to lowering the increase in energy demand will come after the turn of the century. These changes in lifestyles contribute to the virtual stablization of energy consumption per person from 2000 to 2025, as depicted in Table 4-1. In other words, beyond the year 2000, a sustainable level of energy use will make much smaller, additional demands upon energy supplies. In total, primary energy requirements are shown to increase by only 25 per cent over the 25-year period, and a significant part of that demand is supplied from renewable resources and byproduct sources of energy. That "steady state" society is not a static one. The processes of transition will continue, but the strains of the energy transformation should be less after the year 2000. However, that condition of a developing, disciplined pattern of energy demand can only come about even in 25 years' time if systematic planning and preparation for it is undertaken from now on.

The long-term transformation of demand begins with a recognition that we are at a point of sharp discontinuity in the use of energy as a support system for human settlements. At this point of the transition, uncertainty is increased and the risks are greater and less calculable. Elements of both caution and aggressive action, flexibility and resiliency will co-exist. Large-scale energy developments can proceed alongside small, experimental or local, innovative approaches in which new technologies and new institutional arrangements are devised and tested. Smaller community developments, which are more energy self-reliant, can be compatible with the expansion of larger communities and sophisticated large-scale energy support systems.

Society will be called upon to devote substantially more time, effort and material resources to energy-related activities -- those which are demand-reducing and those which increase and substantially alter energy supplies. We are called upon to accept the risks and the costs of designing a new energy system. The transitions in society can then offer immense opportunities for new dynamics in Canadian society. Industrial and regional development, housing and urban design, transportation systems, commercial activity, export opportunities and supplying the greatly changed and enlarged energy industries can all add an immense drive and purpose, all involving a high degree of public participation. Nothing about this process of change is easy or cheap. However, drastic, less acceptable changes almost certainly will come about by sudden wrenchings of society if they are not introduced by more gradual, planned transitions.

5 WHAT ENERGY CAN WE HAVE?

Chapter guide

- *The principal supply objective is to reduce Canada's dependency on imported oil to negligible amounts by the year 2000.*

- *The difficulties of achieving an adequate supply of energy from Canadian sources centre not on any inadequacy of physical resources but on the application of human resources -- technologies, economic feasibility, institutional arrangements, management systems and social acceptability.*

- *By the year 2000, and to an increasing extent to 2025, Canada's energy supply will come in large part from resources which are only now beginning to be significant -- nuclear power, oil sands and heavy oils, frontier oil and natural gas, renewable resources and "byproduct" energy (biomass, solar, urban waste, co-generation, tidal, wind, peat), and converted forms of energy (LNG, SNG, hydrogen, synthetic liquid fuels).*

- *The transformations are only barely achievable if current beginnings are rapidly expanded into programs on a scale never before undertaken in Canada (or elsewhere).*

- *The range of supply possibilities appears to be great but, in practice, the choices are very limited.*

- *Electricity will be Canada's dominant form of energy. Beyond 2000, nuclear generation is likely to become increasingly dominant, but electricity from renewable resources will reach significant amounts.*

- *Oil will continue to be perhaps the second largest component of Canada's energy supply at least until 2025.*

- *Increased quantities of natural gas are an important part of total energy supply, with markets developed on an assured supply basis. Natural gas from western Canada would be supplemented by frontier gas, imported LNG and SNG.*

- *Coal will have substantial additional uses beyond thermal generation of electricity but, like other energy resources, faces many difficulties including environmental and land-use.*

- *Development of the individual supply capabilities are brought together for coordinated action within a consolidated energy supply program.*

Chapter 5. WHAT ENERGY CAN WE HAVE?

The principal objective of our energy supply policy is to make Canada essentially independent of net energy imports by 2000. Imports of energy commodities would be determined by their competitive price and would continue to serve regional balances, but to a much smaller extent than at present. In short, imports would be a matter of choice, not necessity. Exports of energy commodities and energy-intensive products would depend upon competitive international market factors, after allowing for assured long-term security of supply for Canada.

Indicative targets of supply

Based upon the following assessment of energy supplies, a number of indicative achievement targets have been established. These include:

- Increase by one-half by the year 2000, the production of oil in Canada, principally from heavy oils and oil sands, making appropriate use of additional supplies from new discoveries and enhanced recovery methods; at least maintain that higher level of production to 2025.

- By 2000, reduce oil imports to not more than 10 or 15 per cent of total oil requirements (less than 400 000 barrels per day compared with over 600 000 barrels per day in 1977); reduce oil imports further from the year 2000 to 2025.

- Increase natural gas production by at least one-half by 2000, and maintain or increase it further by 2025.

- Increase electricity generation by almost four times by 2000 and increase it further by 2025 so that a much larger proportion of total energy supply is met by electricity. The increase will require a very substantial expansion of nuclear power as well as hydro and coal-thermal electricity generation.

- Increase coal production by four to five times by 2000 and increase it further by 2025 so that coal is meeting many energy uses in addition to the generation of electricity.

- Increase the supply of renewable and byproduct energy resources so that, by 2000, they are supplying the equivalent of about 400 000 barrels per day of oil, and one million barrels per day by 2025.

The above targets will be extremely difficult to achieve even if we begin now explicitly to try to achieve them (or some equivalent variation of them). The targets represent a great structural change in the ways in which energy will be produced and used if a suitable matching of supply and demand is to take place. Some features of those changes are outlined in Chapter 6.

To reduce our dependency on oil, particularly imported oil, will require that appropriate, alternative fuels from Canadian sources are competitively available.

Bountiful but difficult supply situation

In relation to population, perhaps no country in the world is better served than Canada in the vastness and the variety of its energy resources. But in few places have the problems and puzzles of unlocking those resources so taxed man's ingenuity and efforts. In few places are the costs of finding, accessing, transforming and transporting the resources likely to be higher -- at least initially. The challenge for Canadians is to overcome those obstacles and to secure, as careful and prudent use requires, the necessary energy from those resources.

Achievement of a satisfactory energy supply does not simply involve "picking a winner" and going after it. When all of the supply possibilities are examined closely, one feature stands out. <u>There is little or no margin of reserve in what can be produced and what will be required</u>. Only coal and nuclear power appear to offer reserve production capabilities. Canada's energy supply options are confined to striving very hard to achieve a little more of one fuel to compensate for having somewhat less of another. Satisfactory energy supply will involve ever-changing combinations of resources as some sources of supply diminish and new sources of supply come on stream. Some margin of reserve -- some flexibility and resiliency -- is essential particularly during times of great transition. Resiliency cannot rest on indecision or procrastination. A capacity for risk-taking and forceful leadership has perhaps never before been more necessary. Each of the supply possibilities requires careful staging through long lead times (10 to 30 years) in order to meet the complex pre-conditions of supply. <u>Hence, there is an urgent requirement for concerted action</u>.

Pre-conditions to initiating new energy supplies

Any energy resource becomes a practical source of supply only when certain conditions are met. These include establishing:

- resource base;

- technological feasibility;

- economic viability;

- social and environmental acceptability; and

- institutional feasibility.

These pre-conditions also require that the necessary managerial, manpower, financial and the material and equipment supply capabilities are put in place to bring the projects to fruition. Future supply requirements are so large and so complex that a comprehensive and systematic approach is needed to meet the pre-conditions and to achieve the coordinated staging through time. Components of the complex supply system will have to be "targeted" well in advance, with the targets revised as necessary. Hence, a coordinated approach is needed, involving the energy supply and support industries, governments, and the public.

Potential energy supplies

This chapter outlines energy supply potentials for the years 2000 and by 2025. Achieving the necessary levels of performance for each energy resource individually rests on the fine edge of the "barely possible". A balanced combination from among the potentials, to meet new patterns of demand is illustrated in Chapter 6, and a number of possible constraints in the factors of adjustment (prices, financing, etc.) are the subject of Part III of the report. In total, the supply combinations are regarded as a strategic issue area for intensive investigation and concerted action within a consolidated energy supply program.

Oil

The heavy reliance of the economy on oil will be met for a number of years by supplementing Canadian production with increasing quantities of imported oil. In the absence of any large, new Canadian discoveries, production of conventional oil, even with enhanced recovery methods, is expected to decline by 2000. In assessing the possible increase in imported oil, a recent report by the National Energy Board (NEB) stated: "It appears that Canadians must begin to face up to the prospect of supplying imported crude oil to refineries that have for a quarter of a century used only indigenous feedstocks".[1] In those circumstances, imported oil would be required in Ontario as well as in Quebec and the Atlantic provinces. In the NEB's estimate, imports could be called upon to supply more than 50 per cent of Canada's oil requirements and perhaps as much as 85 per cent by 1995. The domestic production of oil, both conventional and from

1 National Energy Board, "Canadian Oil Supply and Requirements", Ottawa, February 1977; page 85.

the heavy oil deposits and the oil sands, might be just over one million barrels per day in 1995 compared with a demand for oil at that time of nearly 2.5 million barrels per day. More than 50 per cent of the oil production in 1995 would come from the oil sands and heavy oil deposits. The National Energy Board is currently re-assessing those relationships, and early testimony suggests that the imbalance might not be quite so great.

This Energy Futures report gives top priority to preventing a reliance on imported oil to anything like the extent which the NEB assessment indicates as probable. The objective of this present assessment is to reduce imported oil to a minor part of Canada's oil requirements by the year 2000, and to ensure that it remains an insignificant part from that time forward. Canada's oil potential is examined within the context of that objective, recognizing that to produce the requisite quantities of oil will be an unprecedented undertaking even if the reserves are there and even if the demand for oil is greatly curtailed. Canadian-produced oil will then have to be moved into Quebec and the Atlantic provinces to a greater extent than now provided for by the Sarnia-Montreal pipeline.

The assessment of oil reserves and of rates of production (producibility) depends very much on the price of oil, the "net-back" to producers and the costs of finding, producing and processing the oil. A balanced disposition of all products from the oil refinery is an important component of that economic viability. The expectation that the real price of world oil will likely double before the year 2000 sets one basically favourable condition for increased exploration and production. The price of oil in Canada is expected to move to world-competitive levels. However, the higher prices might not come soon enough to ensure that production increases in time to avoid serious supply dislocations. The bringing on of new supplies is a long process. Hence, the timing of price increases, or finding ways to act in

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"If we are to avoid the risk of seriously increased real unit costs of energy in the United States, the new low-cost sources should be ready to pick up much of the load by 1975 or sooner."

-P.C. Putman, "Energy in the Future"; D. Van Nostsand Company, Inc., 1953.

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anticipation of them are especially important. Efforts will have to be greatly intensified between now and the year 2000 to bring on the necessary supplies of oil.

No complete assessment of supply is made here of new oil resulting from exploration in the conventional oil regions in Alberta and Saskatchewan, or in the frontier areas of the Mackenzie Delta, the eastern Arctic and offshore along Labrador and the East Coast, or for additional supplies available from using enhanced recovery methods in existing fields. Only a small allowance is made for oil from them. The increase in potential oil supply is expressed mainly in terms of production from the heavy oil deposits and from the oil sands. Recovery from the oil sands includes that from surface mining and, later, by in situ methods (and, possibly, by "intermediate depth" recovery -- between the surface deposits and the deeper deposits appropriate to in situ methods). There are extreme difficulties in achieving the pace of increased oil production which is shown as the target in Table 5-1. If favourable results are obtained at competitive prices from new discoveries and by enhanced recovery of conventional, light oil, the production from the oil sands and heavy oils could be correspondingly reduced. However, the total commitment of productive resources, financing and of effort is likely to be about as difficult to achieve.

Heavy oils and oil sands - no easy solution

The heavy oil deposits and the oil sands in Alberta and Saskatchewan, taken together, are estimated to hold possibly one trillion barrels of oil in place.[1] Perhaps only 10 or 20 per cent of that, or 200 billion barrels of oil, might be technically recoverable over the next 50 years. The cumulative production of oil implied in Table 5-1 would be perhaps 30 billion barrels by 2025, well within the assumed technical production <u>potential</u>, though by no means an <u>assured</u> supply, given all of the attendant requirements of production.

Technologies have been developed which permit surface mining of oil from the oil sands. Other technologies permit in situ recovery of oil from the Lloydminster heavy oil deposits. Improved technologies could increase the efficiencies of oil production from these sources. In addition, efforts are being made to produce oil by in situ methods from the vast potential of the oil sands. The most concerted of the RD&D (demonstration) efforts for in situ recovery of oil from the oil sands are organized under the direction of AOSTRA (Alberta Oil Sands Technology and Research Authority). That agency represents an excellent example of government-industry coordination for the management of intellectual properties and for case-study experimentation and

1 See also: "Oil Sands and Heavy Oils: The Prospects", Department of Energy, Mines and Resources, Ottawa, Report EP 77-2.

TABLE 5-1

Illustrative, Potential Production of Oil[1]

	Potential level of production by 2000	Potential cumulative effect in 2000
	(thousand barrels per day)	
1. Conventional light and installed heavy oil and oil sands production[2]	1 000	1 000
2. Expansion of Great Canadian Oil Sands and Syncrude	75	1 075
3. Addition of 5th and 6th surface oil sands plants	250	1 325
4. Expansion of heavy oil production	175	1 500
5. Addition of 7th and 8th surface oil sands plants	250	1 750
6. 1st and 2nd full-scale, in situ heavy oil production units (including Cold Lake)	250	2 000
7. 9th and 10th surface mining plants	250	2 250
8. 1st and 2nd in situ (Athabasca) oil sands production	250	2 500
	2000 - 2025	
	by 2025	in 2025
9. Decline in producibility from conventional oil	-750	1 750
10. Net additions to surface mining of oil sands (after allowing for decline in early mining)	200	1 950
11. Expansion of Lloydminster and Cold Lake in situ heavy oils	550	2 500
12. Further expansion as in (11)	600	3 100
13. Additional in situ oil sands production	650	3 750

1 Assumes higher world and Canadian oil prices and progressive intensification of effort. Increased production of conventional oil, including enhanced recovery, and of frontier oil might alleviate somewhat this extremely difficult program of expansion, but perhaps make the total oil supply task no easier.

2 As contained in the NEB estimates (ibid.), carried forward to 2000.

demonstration. In some respects, AOSTRA is reminiscent of the scientific, management and financial organization initiated more than 30 years ago to develop Canada's successful nuclear capability. The R&D efforts will need to be well coordinated and supported for many years. Perhaps no other activity in energy resources merits such wholehearted support as oil extraction and processing from the heavy oils and oil sands. It offers an opportunity for a unique Canadian achievement of outstanding proportions -- one capable of establishing scientific, management, financial and commercial leadership on a world scale.

Increasing requirements for heavy equipment offer new opportunities for Canadian equipment suppliers.

The production schedule shown in Table 5-1 is pushing to the outer limits of feasibility to the year 2000. It requires bringing into production a new oil sands plant about every 18 months -- in contrast to one every five or six years at present.

The heavy oil recovery and processing plants are required over the same time. By the year 2000, oil production of 2.5 million barrels per day would exceed by about one-half the 1977 levels of production from all sources. Even so, Canadian oil would then supply less than one-third of Canada's total primary energy compared with a capacity to supply nearly 40 per cent at present. To adjust demand to accommodate so great a reduction in the share of oil might be as difficult as to bring on stream the additional oil. At present, there is no reason to suppose that such a pace of construction could be maintained, even if technological problems of in situ production are solved prior to 1980.

If it were possible to build the oil sands and heavy oil plants at an average cost of $4 billion (1977$), the plants would cost approximately $70 billion. That is a magnitude of capital expenditure for heavy oils and oil sands far in excess of anything heretofore contemplated. The corporate structure, the economic and environmental feasibility and the methods of sourcing the funds call for new management organizations.

In addition to financial requirements of unprecendented magnitude for projects of that type, the requirements for equipment, materials, skilled labour and for the supporting infrastructure and communities during the construction phase and, subsequently, for the operation of the plants, must be addressed on a full systems approach. Environmental and other social concerns could render impractical, or seriously delay, a program of that magnitude. The jurisdictional, regional and provincial implications are likewise great, particularly since the objective is to extend the market for Canadian oil into Quebec and the Atlantic provinces, building the requisite pipelines to do so. Agreements between the federal and provincial governments, between governments and industry, between producers, customers and transporters of oil will require preparation which could only be successful if immediate beginnings dealt with the projects on a comprehensive scale. The management and organizational burdens are immense for so vast a project, implemented on so rigorous a timetable.

Even were the total project to be halved, the aggregation of problems and the staging requirements would tax our ingenuity, our efforts and our resources. However, if oil production from all sources combined falls significantly short of the scale here allowed for, Canada's energy balancing problems could become disruptive of social well-being. There are no easy alternatives. Even with the above programs, oil would supply a much smaller proportion of total energy than at present, and other energy resources would have to be increased by an even greater amount to make up the difference. Such is the staggering challenge facing Canadians.

In the period from 2000 to 2025, the magnitude of the oil supply problem remains great, but by that time basic technological, organizational, financial and logistical requirements should be

more manageable. Once the share of oil has been worked down to, say, one-quarter of Canada's total energy requirements, that basic oil supply probably can be sustained for a very long time. Thus, oil remains a very significant part of Canada's sustainable energy balance to 2025 and beyond.

Conventional and frontier oil

A greater proportion of total oil than that shown above might come from discoveries and enhanced recovery in the conventional oil producing areas and from the frontier areas. The illustration of production from the oil sands and heavy oils is not intended to deny that possibility. However, in many instances, the technological, economic, social and institutional requirements of these alternative sources of supply, while different in kind, would not be easier to meet than those for the oil sands and heavy oils. Efforts to prove up these sources of supply, and the feasibility of bringing them into production and to market within some established timetable remain a high priority. They represent an additional program of action to be carried out at the same time as the progressive expansion of the oil sands and heavy oils.

Innovative approaches to offshore resource recovery.

One of the strategic areas for concerted action is the establishment of a comprehensive planning and programming capability, involving all of the appropriate decision-makers and the public. The purpose would be to assess the entire oil supply potential from all sources in ways which identify how best to proceed within a comprehensive program and with appropriate staging of projects year-by-year. An overall management, or steering, process is required.

Natural gas

The principal objective for a natural gas program is to maintain and preferably increase the share of natural gas in Canada's total energy supply. That will require an increase in natural gas production by at least one-half by 2000. Natural gas, like oil, is a premium fuel -- clean, versatile, easily transported. It also has important non-energy uses of which petrochemical and ammonia (fertilizer) manufacture are especially critical. Natural gas adds resiliency to energy supplies because of the wide range of interfuel substitutions which it supports.

At present, natural gas provides just under 20 per cent of Canada's primary energy. However, more than 40 per cent of production is exported. Present export contracts expire through the 1980s and are terminated by 1992. In this assessment, no allowance is made for exports beyond that time, but a decline in producibility will occur in existing wells. Many new wells will be required to provide the increasing Canadian requirements.

Gas pricing

A significant factor in the sale and use of natural gas is the price of alternative sources of an equivalent amount of energy. Some of the complex pricing considerations are noted in Chapter 9. Gas pricing, in conjunction with other energy pricing, is another strategic issue area for concerted action. For purposes of this chapter, two of the important competitive price considerations are the price of furnace oil for space heating and the price of "residual oil" for industrial steam generation and process heat. For a time, because of competitive pressures from these fuels, natural gas might have to be priced lower relative to oil than its comparative thermal value would indicate. However, as the real price of oil increases, there will be scope for greater price differentials and still leave incentives to bring on virtually all of the potential gas supplies. The price increases can be expected to make economically attractive Mackenzie Delta gas, eastern Arctic gas, and offshore gas along Labrador and other east coast locations, if sufficient quantities are discovered to warrant production and the costly transportation to market. Exploration activities, for example, have been greatly encouraged in western Canada in the past year as a result of higher prices and

provincial and federal fiscal incentives. Further increases in natural gas prices will greatly ease the financing of additional supplies. However, new methods of ownership, control, management and financing will be called for if the extensive exploration, production, transportation and marketing system are to be provided at such a forced pace as required in the above gas target.

Natural gas "wedge"

As natural gas reserves increase, an additional "wedge" of natural gas can be driven into the domestic market, based upon assured supplies for 30 years. The gas could replace, particularly in Ontario and Quebec, significant quantities of oil which are now used for space heating and industrial purposes. For the present, further market penetration is being impeded by the abundance of residual oil from oil refineries. However, that is expected to be a fairly short-term anomaly, for which adjustments can be made. It is not expected to impede gas marketing over the longer term. The relationship between refinery operation and the new patterns of energy use, including the use of natural gas is a critical part of the recommended consolidated energy supply program.

One difficulty with the increased use of natural gas for space heating is the great seasonal variation in demand. Ways to smooth out demand might include increased gas storage capacity, lower rates of production, possibly with paid "stockpiling" in the ground; dual thermal facilities in industry which would use natural gas and residual oil, or some other energy source in complement; a possible offsetting seasonal use for non-energy, feedstock purposes or for grain drying, and possibly spot, or short-term, export sales to ease temporary surpluses. The detailed assessment of the most efficient methods to deal with problems of this nature is part of the coordinated management approach to a long-term, national energy system.

An increased supply in natural gas would come into Ontario, Quebec and the Atlantic provinces to replace part of the imported oil. To reach the eastern regions, a gas pipeline (such as the proposed Quebec-Maritime pipeline) would be built and provided with a reversible flow capability. The gas supply would be cascaded into the market, coming first from an increase in supply in the western provinces, followed probably by Mackenzie Delta-Beaufort Sea gas, then eastern Arctic (by LNG tankers and/or pipeline), then possibly by gas from the Labrador-East Coast region. Shortfalls or additions might be met for a time by imported LNG supplies, supplemented by SNG produced from coal, methane from biomass, coal gas, marsh gas, etc. Quantities of hydrogen could be added to supplement the natural gas supplies. Thus, an additional gas supply would be assured to allow the substitution for oil in the vulnerable central and eastern Canada markets.

Supply possibilities

To maintain or increase natural gas in the space heating market (and perhaps for some additional industrial uses) requires assurance that a supply of gas will be available over a 20 or 30-year time span. Salesmen cannot go out to sell more natural gas unless they can give some assurance of continuity of supply. On the other hand, further exploration and production of natural gas would be delayed if access to additional markets is not available. For a time, this can develop into a "Catch 22" situation -- no increase in sales because there is no long-term security of supply; no increase in supply because there is no evidence of an available market. New management and financial arrangements are likely to be necessary to facilitate the integration of new supplies and uses of natural gas. Table 5-2 illustrates one natural gas supply possibility. Many variants of it are possible, but it does suggest that the maintenance, or some increase, in the share of natural gas is a realistic possibility.

As with oil, the contribution of natural gas will be achieved only with considerable effort, at substantial cost, and with the application of management skills of a high order. At the same time, a serious shortfall in natural gas supplies would place a heavy burden on other energy resources, or require further reduction in demand, probably with great economic and social strain. A supply shortfall probably would be felt principally by further increases in coal and nuclear generation of electricity.

Getting natural gas to more Canadians requires more pipelines.
(National Film Board Photothèque)

If natural gas is to continue to provide about 20 per cent of Canada's primary energy, about 3 200 billion cubic feet would be needed by 2000, and about 4 000 billion cubic feet by 2025. Maintenance of the existing share falls within the range shown in Table 5-2 but, in the absence of substantial discoveries, would push very hard on production capabilities.

Many other difficult problems must be addressed. The magnitude and pace of market expansion, and the timing or staging of gas supplies from the various potential sources, will require careful planning. Technological innovation over a wide variety of activities will be required, as will appropriate federal and provincial policies to ensure exploration, production, delivery, and the appropriate market expansion. The financing, manpower, materials and equipment supply requirements (predominantly from Canadian sources) are likely to be difficult to bring into place when needed on the scale required. Price increases and favourable price differentials with oil will eventually encourage the increased production and use of natural gas and the increase in supply-industry capabilities. Indicative targets and interim performance targets can test the feasibility and establish the priorities for the natural gas programs. Thus, natural gas can be one of Canada's most prized and strategically important energy resources through the entire 50-year period.

TABLE 5-2

Illustrative, Potential Production of Natural Gas

	1975	2000	2025
		(billion cubic feet)	
1. Conventional production	2 500	1 500	1 000
Less exports	1 100	-	-
Available in Canada	1 400	1 500	1 000
2. "Unconventional" western recovery and Delta-Beaufort	-	2 000	2 000
3. East Arctic	-	800	1 000
4. East Coast	-	100	500
Total above:	1 400	4 400	4 500
Illustrative range:	1 400	2 000-4 500	2 000-4 500
SNG (and imported LNG)		500	1 000

Coal

The objective for coal in this overall assessment is to ensure that, with the application of advanced technologies, its potential uses are fully developed. Coal will then not only provide a much larger relative share of thermal-electric generating and industrial uses, but will also serve a number of other purposes as well. As a result, an indicative target for increased coal production is a five-fold increase by the year 2000 and a further doubling of production by 2025 (Table 5-3).

Coal dominated Canada's energy supply for more than half a century until it was replaced by oil and natural gas in the 1950s and 1960s. Coal already is becoming once again a much more significant source of energy, but the forms of its use are expected to differ appreciably in the future from those of the past.

Constraints to increasing coal production

The basic requirements are present for a substantial expansion of coal production in Canada -- vast coal reserves, adequate technologies for conventional mining, an established industry with its own financing arrangements. However, a number of constraints will tend to limit the potential expansion of coal production over the coming 50 years.

- **Environment, land and water use.** Environment, land and water impacts could become the most significant constraints to substantial increases in the use of coal. The probable magnitude of the mining and use of coal within the next 10 to 20 years will result in an entirely new order of environmental, land and water concerns. Closely related, are other community and social concerns. Environmental problems arise at the mine site, with transportation, and with coal combustion. Combustion brings forth the usual problems of air pollution, and an additional, increasing concern over the possible effects from a substantial increase in carbon dioxide in the atmosphere. Land and water use at the producing site (and possibly of water in slurry pipelines) become critical considerations to the producing provinces as the volume of coal mining increases substantially. The environmental, health, land and water concerns, along with similar concerns elsewhere throughout the energy sector, are here regarded as another <u>strategic issue area</u> for concerted action.

- **Technology.** Mining in mountain strata and in deep sea beds would benefit from technological advances, and a number of impediments elsewhere in the coal industry would benefit from technological innovations. Further technological advances would greatly enhance new uses of coal -- SNG production (especially in situ), coal liquefaction, fluidized-bed combustion, transportation, waste disposal, environmental protection and land rehabilitation.

However, with existing technologies, coal can be mined and used in much greater quantities than at present. Other constraints impose themselves.

- **Equipment.** Advanced underground mining equipment and great draglines for surface mining might well be in short supply and create delays and bottlemecks (and increase rapidly in cost). There is at present very limited Canadian manufacture of this equipment. For imported equipment, demands in the United States and other parts of the world will compete keenly.

Given the magnitude of future equipment requirements in Canada, the development of a Canadian manufacturing capability for many types of equipment and supplies can be considered a high priority matter within an industrial strategy. The equipment and supplies required for coal mining, transportation and use, and for environmental protection, for land rehabilitation and for community services are, in turn, similar to others throughout the energy sector and for other resource industries, all of which would support a much expanded equipment-supply industry.

- **Skilled labour.** Shortages of skilled labour for coal mining and for other heavy equipment operation could quickly develop. Underground mining, using modern equipment, is a highly skilled operation. For surface mining, heavy equipment operators will be in great demand in other places as well as the coal mines. Their skills are readily transferred from one project to another. Coal mining must bid in a very competitive market for heavy equipment operators. To overcome this potential bottleneck requires more than just training programs and high pay. It requires community development programs for young miners, their wives and children.

- **Financial requirements.** Financial requirements are not exceptionally great for individual coal mines although a large mine, together with its transport facilities, other infrastructure and community development, can require capital expenditures approaching one billion dollars. If 10 or 20 such mines are planned for the same 20-year period, difficulties of raising capital by conventional methods could impose significant delays.

- **Government regulation, control and fiscal policies.** Government regulation and control, as well as taxes, royalties and leases, can be a constraint of major importance which can cause project delays, prohibit a project entirely, or reduce the financial attractiveness (and the efficiency) of the operation. Many of the regulations pertain to land use, land reclamation and other environmental considerations which must become increasing concerns for all energy projects. Considerable advance investigation of regulations, fiscal policies and institutional arrangements is required to enable projects to proceed expeditiously and in a well staged manner, maintaining as much consistency and certainty in regulatory and other decisions as possible.

Production and use of coal

The use of coal for the thermal generation of electricity and process heat for industry are the most relevant, traditional energy considerations. (Metallurgical, coking coal is not assessed in this report.) However, the production of coal, or its underground conversion, will be called upon more and more to support other activities. In 1975, more than one-half of the Canadian coal which was mined went to metallurgical uses, mostly exported to Japan. At the same time, nearly one-half of Canada's supply of thermal coal was imported from the United States for use in Ontario for electrical generation. Large quantities of coking coal for metallurgical use also entered Ontario from the United States. As a result, Canada was a net importer of coal, a condition which persisted in 1976 and 1977. The production and use of coal in Canada, therefore, is greatly influenced by the availability of markets and of supplies abroad, and by policies adopted in respect of exports and imports of coal, and energy commodities more generally. Opportunities are likely to arise for Canada to be a net exporter of coal on a large-scale, and policy decisions will be necessary concerning the extent to which exports will be encouraged or discouraged.

Two potential new, energy-related uses of coal could require a very substantial expansion in coal mining. Coal could be used to produce high-pressure steam and hydrogen for in situ recovery of oil from the oil sands and from heavy oil deposits. It could also be used for the production of significant quantities of SNG. If in situ methods for thermal power and for SNG production become commercially feasible, the commitment of very large quantities of coal to the above uses would block off its availability for other uses. In addition to the two additional uses referred to above, the industrial use of coal might increase appreciably particularly as a partial substitute for oil and natural gas, for example, in process heat and in the manufacture of petrochemicals. Coal, so used, would permit the oil and natural gas to enter other markets such as transportation and (for natural gas) space heating. Coal can also be expected to replace some oil in thermal electric generation, especially in the Atlantic provinces and Ontario.

Table 5-3 illustrates a possible coal supply situation in 2000 and 2025. Possible variations are great because each of the sources and uses can change appreciably. The table draws attention to several important relationships in Canada's coal future:

- The increase in production of coal for thermal use is especially pronounced, and would require the equivalent of about 2 new coal mines to be brought into production every year or every 18 months from now until 2000. Given the time taken to bring in new mines (typically 3 or 4 years), that is a very ambitious target.

TABLE 5-3

Illustrative Potential Coal Production

	1975	2000	2025
		(million tons)	
Production			
Metallurgical (mostly for export)	15	30	40
Thermal	13	100	160
Other uses	-	20	100
Total production	28	150	300
Metallurgical imports	13	25	25
Thermal Coal			
Production (above)	13	100	160
Imports	12	25	25
Total thermal	25	125	185

Annual potential increase in production: 1975-2000, 6.7%
2000-2025, 1.6%

- An additional problem, as with all other energy supply options, is to determine sufficiently far in advance whether so great an increase in production will be necessary, and, if so, when. Expansion in coal mining capacity cannot get too far ahead of demand. On the other hand, how closely is demand to be controlled, or energy resources allocated; by whom and for what reasons? "Managed demand" includes both domestic and export and, together with managed production, can apply to all grades and locations of coal, largely determining the rate of expansion of mining capacity.

- It is apparent that, initially, the objectives and priorities of provincial governments across Canada, in assessing coal production and use, can differ appreciably from those of the federal government or from what might best serve a long-term, national adjustment program. Reconciliation of these objectives and programs becomes a matter of high priority for coal as with other energy resources and changes in patterns of demand.

- The increases of coal for thermal electric generation could be curtailed if: other markets for coal are more attractive to the producers or to the governments of the producing provinces; the demand for electricity is lower than illustrated; nuclear

power dominates electrical generation to a greater extent; oil, natural gas or renewable resources become more readily available than allowed for in this assessment, or if the constraints on coal mining prevent such an expansion.

- Coal production for "other" uses, as shown in Table 5-3, reaches significant magnitudes. The increase reflects the assumed growth in coal demand for steam and hydrogen for oil sands operations, for SNG production, increased industrial use and coal liquefaction. Principal among these other uses, beyond 2000, might be:

  a) industrial uses in addition to metallurgical (e.g. ammonia, methanol, cement manufacture, etc.) .. 20 million tons/yr.

  b) coal for steam and hydrogen for oil sands ..... 20 million tons/yr.

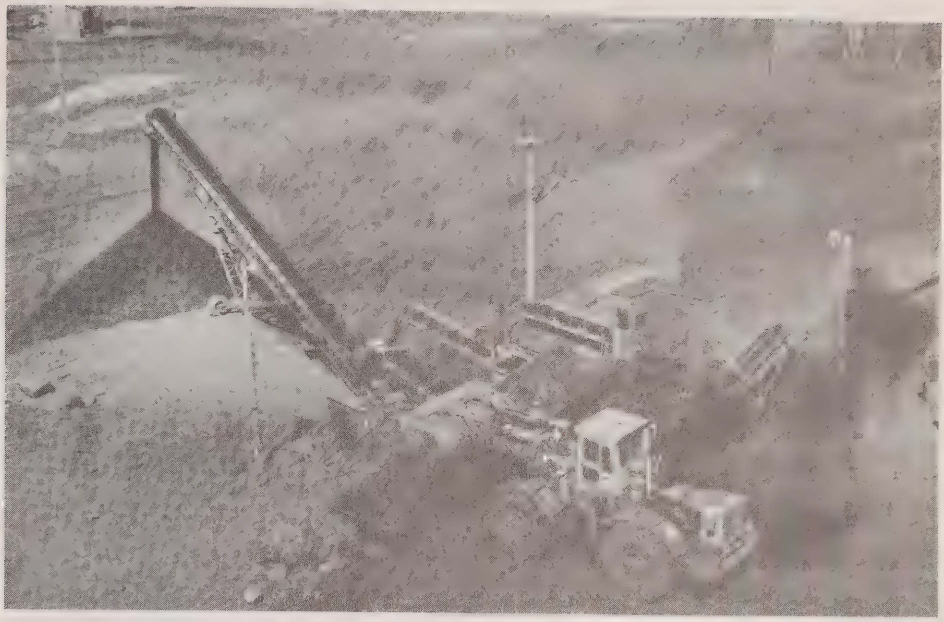
  c) coal for SNG surface plants .... 30 million tons/yr.

  d) accelerated shipment of thermal and metallurgical coal to central Canada .... 10 million tons/yr.

- Exports of both metallurgical and thermal coal are assumed to be set by limitations to the rate of increase in production and by government policies to restrain rates of growth in coal mining and export. Potential export markets are expected to be larger than Canada's ability to meet them. Exports of coal could take indirect forms such as electricity, SNG or industrial products.

- Imports of both metallurgical and thermal coal are assumed to be limited by available supply, particularly if the United States has difficulty meeting its own greatly expanded coal requirements or is under pressure to export to countries with severe shortfalls in energy supply. The United States is likely to pursue a much stronger coal option than Canada with the result that the increased requirements for metallurgical and thermal coal in Canada would have to be met mainly from production in Canada.

- The magnitude of the potential increase in coal production could become a dynamic factor for a broad range of industrial and service activities. Coal production could become a strategic element in Canada's long-term economic and community development.



A greatly expanded use of coal means more equipment, more materials handling and more land reclamation.

Increase in coal supply is mostly in western Canada

The opportunities for increased coal production in the Atlantic provinces are perhaps confined to uses in that region and to some export of coal. The principal expansion in coal mining is expected to take place in Alberta (plains, foothills and mountains), British Columbia (Crow's Nest Basin, Hat Creek and other foothills and mountain locations), and in Saskatchewan (lignite and surface mining for local use and, possibly, shipment to Manitoba and Northwestern Ontario). Figure 5-1 sets out an illustrative regional distribution of principal sources of coal production by 1990.

Coal prices

Conditions pertaining to coal will include a number of factors making for significantly higher prices.

- The mining activity for bituminous thermal coal competes for equipment, supplies, labour and infrastructure with metallurgical coal (though, at times, they are co-produced). Both capital costs and operating costs for thermal coal are likely to increase substantially as coal mining activity in Canada and abroad exerts much heavier pressures on the support industries. Prices will reflect these higher costs.

Figure 5-1. Regional distribution of coal production.

- To the extent that thermal coal (after allowance for differences in handling costs and convenience in use) is priced at thermal equivalence with oil for electrical generation or process heat, the price of coal will tend to move up as oil prices increase. Increased government tax and royalty collections from coal production and sale might ensure that price equivalence, thus limiting any price advantage which coal otherwise might have and which would encourage the substitution of coal for oil.

- Because Canadian production and use of coal are closely tied to world supply and demand, the price of thermal coal in Canada will be greatly affected by world coal prices, and by the availability of supplies and markets abroad. The anticipated very substantial increase in the use of coal to meet world energy demands will enhance this international price impact, tend to make Canada a net exporter of coal and to increase the price of coal in Canada.

- The impact of substantial, new or expanded uses of coal will tend to increase the price of thermal coal for conventional uses and make coal less competitive for the generation of electricity or for other industrial uses particularly in Ontario, Quebec and the Atlantic provinces. Even now in Ontario, price, security of supply and convenience factors favour a more rapid expansion of nuclear power than coal-generation of electricity.

- The impact of increased environmental safeguards, other public safeguards, government regulations, transportation costs, the use of more remote and difficult sites will all tend to increase costs and, hence, coal prices.

No precision can be attached to the probable, combined impact of factors such as the above in the various regions of Canada. By the year 2000 and beyond, other demands on coal and other constraints such as environmental, and land and water use might well be more significant determinants of the availability of coal for electricity generation and for conventional process heat than will be the relative price of coal.

Coal transportation

By the nature of mine locations and the principal markets, long-distance haulage is a significant feature of coal marketing. Rail and ship transports are predominate forms of transport, but slurry (water and coal) pipelines are expected to be economical when large quantities of coal (e.g. something in excess of 10 million tons per year) are moved over intermediate distances (e.g. from the Rockies or foothills to the Alberta oil sands).

Electrification of some railroads and considerable upgrading of rail and port or terminal facilities are important considerations when assessing the future relationships of transportation and coal. If coal is gasified or liquefied at the mine site, conventional types of oil and gas pipelines could be adapted to move the products. The various modes of transportation are likely to develop incrementally as an immediate need is demonstrated. However, there is advantage in assessing long-term needs so that ad hoc changes are not rendered inefficient or obsolete within a few years, to be replaced by a more adequate system which could have been installed in the first instance. Whatever approach is taken, the total transportation requirement will likely be so great that coal transportation becomes an important subject within the <u>transportation energy program</u>.

A long-term, coordinated management approach calls for a high level of consultation, in a systematic way, between the coal mining industry, the transportation, material and equipment, financial, construction, and supply industries, for manpower and community planning, and between the industries and the federal government and the governments of the producing and consuming provinces.

Electricity

Electricity is expected to increase substantially as the supply of oil becomes increasingly constrained. <u>The indicative target for electricity is to increase generating capacity nearly four-fold between now and the year 2000, and to increase it by one-third again between 2000 and 2025</u>. The share of electricity in Canada's total primary energy supply would increase from about one-third at present to nearly one-half by the year 2000, and would continue to increase at least until 2025. Thus, Canada, in keeping with other countries of the world, will be moving from a predominantly oil economy to a predominantly electrical economy. The timing of the expanded electricity systems is of critical importance, as is the distribution of generating capacity among resource inputs, and maintenance of appropriate regional balances. The increased export of electricity, of electricity embodied in goods and services, and of equipment and professional services for electrical generation are significant possibilities. The greatest difficulty in the transformation toward an "electrical society" can be expected to come from the difficulties in transforming end-uses, not from difficulties to supply electricity.

Electricity as an energy "resource"

Electricity is not a primary energy resource, but a convenient energy carrier which enables a basic energy supply to be more easily transported and used. It can bring into use much of the renewable resource potential, provide energy storage (e.g. pumped

water in reservoirs for hydro power) and other secondary forms of energy (e.g. the production of hydrogen by electrolysis). Additional electrical supply potentials can be established in small, local units, or as part of large-scale electrical grids. The increase in the relative share of electricity would represent a convenient transition, one which provides comfortable living in accustomed forms. It also supports advanced, automated forms of production and communications.

In addition to a substantial, additional penetration into energy use, particularly as a partial replacement for oil, electricity offers a "fall-back" capability to meet additional energy requirements if other resources are not available in the amounts anticipated. Electricity offers perhaps the only assured measure of flexibility and resiliency to the energy system. A margin of reserve generating capacity is required to provide flexibility and resiliency.

Electricity also has disadvantages. Environmental concerns associated with coal, hydro power and uranium-nuclear constrain the increased use of electricity. Acquisition of the basic resources and transmission of electricity are costly; land-use requirements are sizeable, conversion losses are high for thermal generation and, therefore, technical efficiency is low.[1] It is generally the most capital-intensive of energy forms, but once in place, nuclear and hydro plants are largely insensitive to inflation. Electricity costs typically have been high relative to oil and natural gas and it has, therefore, come to be regarded by some as a luxury form of energy even though it has also been the essential foundation to the most energy-intensive, and advanced economic and social processes.

The structural, end-use changes required for a massive substitution of electricity for oil take a considerable length of time to put in place. The limitations to the pace at which end-uses can be converted to electricity are likely to impose a significant constraint on the expansion of the use of electricity. Financial strains resulting from the need to provide many additional, large-scale generating plants is another potentially important constraint. Protests by interest groups opposed to nuclear, hydro or coal-thermal generation are another potential constraint to sizeable, or adequate, expansion of electricity.

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1 To assess adequately the efficiencies of the various energy resources, much further investigation is needed of total systems losses and efficiencies from point of initial production to the final use by the consumer - i.e. primary, secondary and tertiary conversion losses and efficiencies. At point of use (tertiary), electricity efficiencies typically are high relative to oil, natural gas and coal.

The problems associated with electricity are better known than those associated with new sources of energy supply such as frontier oil and gas, in situ oil sands production, greatly expanded production of coal, or even the renewables such as direct use of solar power, biomass or wind. At the technology and resource level, the problems to be overcome for an expanded electrical option are likely to be small. The costs to society, in the form of economic and social disruption, if an adequate electricity supply is not available when needed, would be very high indeed.

The cost of electricity has risen sharply in the last two years, reflecting in large part a "catch-up" with the earlier increases in the prices of oil and natural gas. However, long-term future electrical costs might very well increase less rapidly than oil and natural gas, first because fuel costs for electricity (especially nuclear and hydro) are a smaller percentage of total costs, and secondly because all three basic resources for electrical generation (coal, water power and uranium) can establish costs and prices independently of oil and natural gas. (Electricity pricing is discussed further in Chapter 9.)

Electricity has other significant advantages. It permits, by means of co-generation of heat and electricity, the direct supply of thermal energy for space heating, or electricity can be co-produced with thermal energy requirements. Undoubtedly, co-generation will be greatly increased and that, in turn, will improve the cost effectiveness of electrical generation. Secondly, electrical generation will become a principal means of allowing renewable resources (solar, wind, biomass, geothermal, tides and waves) to penetrate the energy system. The electrical-renewables combination is also linked with co-generation of heat and electricity and with other ways to use byproduct energy resources such as urban and industrial wastes.

Electrical capacity -- How rapid an increase?

Increases in installed electrical generating capacity are driven by perceived increases in demand 10 to 20 years into the future. Electrical supply, for the most part, is limited by those perceptions of future demand and by the ability to finance increased capacity. Controversy has arisen recently as to whether electric power utilities should have so much responsibility and control over the provision of reserve capacity. A related controversy is whether the utilities should be able to support those decisions by fairly independent access to financial markets; be permitted to increase utility rates and, in large part, determine rate structures. The resolution of those controversies is of critical importance to the long-term future of electricity and of energy in Canada. Three observations are particularly relevant to this assessment:

- Electrical utilities, for the most part, have given consistently good service in all parts of Canada, based on technological competence, responsible fiscal management, and maintenance of reserve generating capacity; this record, together with provincial government financial guarantees has established a fine credit rating without placing an undue burden on consumers.

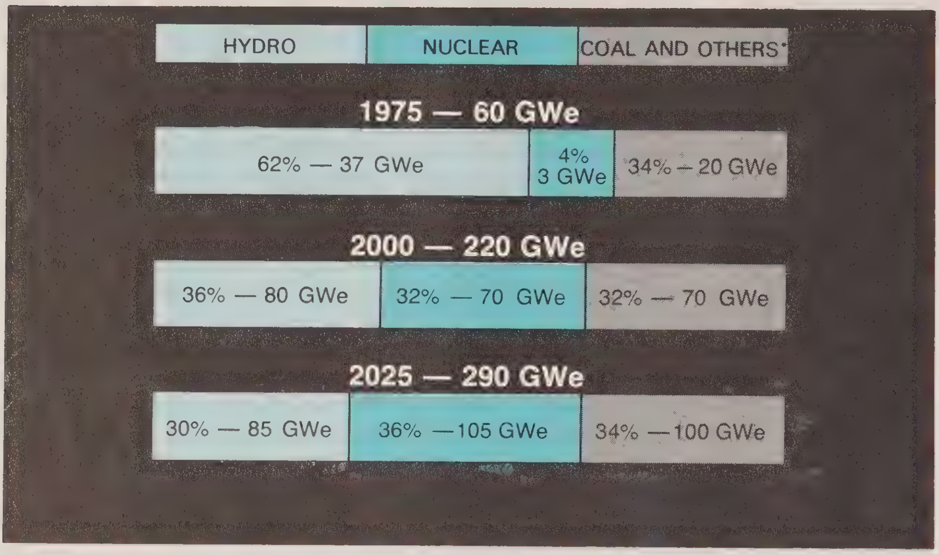
- Substantial changes in the accountability of electrical utilities, and in electrical rate structures can be expected.

- Utilities will be called upon to manage electrical systems under more trying circumstances in the future than in the past, possibly also incorporating a new range of responsibilities. In those circumstances, innovative management techniques are required, related, for example, to maintaining the integrity of electrical networks and phasing in large new supplies. Improved financing arrangements, new rate structures and new forms of public accountability undoubtedly are called for.

Electrical utilities across Canada have fairly unanimously planned for an expansion of generating capacity based on anticipated growth rates in demand of 6 or 7 per cent a year. Such expectations are not surprising, given the experience of the past 20 years when the annual rate of increase consistently averaged 6 or 7 per cent. Moreover, no responsible management could take a chance on being underbuilt. To increase generating capacity by the installation of sizeable additions to generating capacity takes a decade or longer, and a serious shortfall at any time within that period could create great hardship and economic disruption. It is more appropriate to err initially on overbuilding. Then, if surplus capacity is developing, the rate of planned expansion can be slowed. To try to rectify past underestimations of need and put up with disruptions of supply is a much more costly option. The "insurance" cost is low in comparison. Moreover, the spot sale of excess electricity to neighbouring provinces or to the United States can provide a profitable way to manage temporary overcapacity.

Most of the expansion of electrical generating capacity throughout the 1980s is already committed. Over the long term, the rate of increase in installed capacity can perhaps be greatly reduced, thus easing the pressures to increase capacity so rapidly after the mid-1990s. Figure 5-2 illustrates a situation in which electrical generating capacity increases rapidly through the period 1975-2000 as a whole, but not as rapidly as the 6 or 7 per cent growth rate which sometimes has been postulated for the next 10 or 15 years. From 1975 to 2000, the average rate of increase would be less than 5.5 per cent a year, and from 2000 to 2025, just over one per cent a year -- perhaps an unrealistically low rate of expansion and presented in that comparison as if the reduction were more abrupt than it would, in fact, be.

The capacity illustrated in Figure 5-2 is based upon supply capabilities, not all of which might be called into use -- see Chapter 6 regarding energy balances.



*"OTHER" in 1975 mostly oil and natural gas;
in 2000 and 2025, renewables, co-generation, etc.

Figure 5-2. Potential electrical generating capacity by source, 1975, 2000, 2025.

Difficulties arise if efforts are made to increase the share of electricity too rapidly. Beyond some point, interfuel substitutions cannot readily be made.[1] An increase in the share of electricity to 50 per cent of total primary energy by 2000 and possibly to 55 per cent or 60 per cent by 2025 would represent a substantial rate of interfuel substitution. Thus, as noted above, the limiting factor to the increased use of electricity is not the basic resource capability but the rate at which patterns of demand will be altered to accommodate more electricity.

1 See, for example, "Energy demand projections, a total energy approach", Department of Energy, Mines and Resources, Ottawa, Report ER 77-4, 1977.

Electricity resource base

Canada has an ample supply of the basic resources for electrical generation -- hydro power, coal, uranium and thorium. In addition, it is well placed to take advantage of additional forms such as tidal and wave power, biomass materials, solar, wind power, and peat, industrial process heat and co-generation. Its ample sources of electric power will enable it, under appropriate conditions, to produce hydrogen as another convenient transformation of energy.

- **Hydro.** Hydro power has long been the mainstay of Canada's electrical generation. In 1975, it constituted 63 per cent of total installed capacity and over 70 per cent of net electrical generation. It contributed about one-quarter of Canada's total primary energy. The magnitude of Canada's hydro power and the manner of its development are impressive by world standards, and permit Canada to participate internationally in the construction of hydro facilities and in supplying their equipment.

From 1977 to 2000, further increases in hydro capacity will be substantial, more or less paralleling the increase in either coal or nuclear. In terms of renewable resources, further installation of hydro power will make the largest contribution. Principal additional hydro potential is located in Quebec, especially in the James Bay area; in Labrador, at Gull Island; in Manitoba along the Nelson and Churchill rivers; and in British Columbia on a number of rivers. Some additional sites are located in the Yukon and Northwest Territories.

By 2000, most of the major, readily accessible hydro sites probably will be developed. While further additions can be expected, they will be more difficult and costly, and less economically attractive relative to coal or nuclear generation. New forms of hydro power may then be added, as well as modern variations of older, little used forms. These include, for example, tidal power, wave power, smaller hydro heads which have not been regarded as economical, and possibly pumped hydro storage using wind power or off-peak electrical capacity. The Bay of Fundy tidal power, for example, might well be partly harnessed before the end of the century. Ocean waves on the west side of Vancouver Island might eventually contribute significant quantities of electricity if the formidable technical problems can be resolved. Additional inland water, including low-head turbines on rivers, and constructed breakwater sites, pumped hydro, etc., might serve local needs and feed some power into regional grids.

In total, therefore, the future potential for hydro power remains impressive but faces Canadians with a series of new challenges, particularly after the remaining, conventional river sites are harnessed. Land-use issues and other environmental concerns, as well as the very substantial capital requirements, will act as major constraints that will require new approaches to overcome.

- **Nuclear electricity generation.** The CANDU reactor has unquestionably demonstrated its technological efficiency and economic practicality. Rapid expansion of thermal-nuclear generating capacity in the past few years and increasing international interest in the CANDU reactor illustrate its increasing technological and economic attractiveness. For Ontario, this source of electrical generation is particularly reassuring because, apart from hydro power which is now mainly developed, the uranium-nuclear source is the only large-scale indigenous power source, so far discovered, which can support the further expansion of the province's energy supply. With minor exceptions, coal, oil and natural gas must all come from outside the province.

Compact nuclear plants have the potential to supply a large part of Canada's energy.

Nuclear power is beginning to be attractive to other provinces as well, particularly at this time to New Brunswick, Quebec and Manitoba, the last two as a follow-up to remaining hydro potential. Nuclear power can be expected to become more competitive and economically attractive. By the year 2000, nuclear power quite probably can become a price setter, not just for electricity generation but for energy more generally. It could become a basic reference price for other forms of energy wherever electricity is substitutable. Coal-fired generators in the Maritimes

and in Ontario already face a nuclear reference price. Even for space heating, which is about 30 per cent of total energy use, nuclear generated electricity might well become competitive as the price of oil doubles and most other energy resources follow oil prices up. Electrical space heating will benefit from moving away from simple resistance heating systems, in some applications, to steam generation for district heating, the use of byproduct heat from electric utilities and the application of heat pumps, heat storage and supplementary heating systems such as solar power.

Major constraints to nuclear-generated electricity are capital costs, public concern about health, safety, security, uranium mining and waste disposal associated with nuclear power, and existing building designs and installed space heating equipment which are based chiefly on oil or natural gas. Less satisfactory (e.g. imported oil) alternatives will continue to be used for some years, even though more aggressive replacement programs might be advantageous.

Serious, world-wide concern about nuclear power might delay or limit its increased use in Canada and elsewhere. <u>Public perceptions of the risks and uncertainties associated with nuclear power are real constraints, the resolution of which is urgently required if a greatly increased nuclear capacity is to be installed</u>. If nuclear installations are to be prevented or seriously delayed because of public concerns which are not being adequately addressed, the entire energy supply system can be placed in serious jeopardy. Energy supply alternatives, which will maintain satisfactory economic performance and permit further advances in individual and social well-being, are not readily available. It might be noted that coal, the principal alternative resource for a substantial expansion of electrical generation, could face problems which might be more serious than those for nuclear power.

The principal public concerns about nuclear power are:

- thermal pollution effects;
- radioactive releases;
- radioactive wastes[1];
- accidents; and
- theft and terrorism.

1 See also "The Management of Canada's Nuclear Wastes", Department of Energy, Mines and Resources, Ottawa, Report EP 77-6, 1977.

Many scientific experts are satisfied that the risks associated with these factors are minimal or can be satisfactorily contained. Nuclear power probably has received far more environmental, health, security and safety investigation than any other source of energy. Multiple back-up and fail-safe devices are used and rigorous regulatory regimes enforce safety requirements. Even so, apprehension continues among some segments of the public. Long and serious attention is needed as to how the experts and governments are to address that unease. A related concern, also under investigation, is the disposal of slag and tailings from the mining of uranium. This poses problems common to all mining operations, although the potential radioactivity of uranium mine tailings adds further difficulties to waste management at the mines. The environmental section of Chapter 12 again takes up this matter.

The efficiency of nuclear generation is expected to be greatly improved over the next 25 years with the possible introduction of new technologies such as the thorium reactor, the organic-cooled reactor and fast-breeder reactors. In this assessment, no estimate is explicitly made of the magnitude and the timing of advanced nuclear technologies, but it is expected that the thorium cycle or other fuel cycles will be required soon after the year 2000 unless substantial, additional reserves of uranium are proven in Canada. No provision is here made for the introduction of fusion power by 2025, or for the small-scale nuclear plant for mobile use, for example, in ships or locomotives. The CANDU-type reactor, together with its other potential fuel cycles, could be more than adequate for Canada's nuclear requirements.

Uranium and thorium

Canada is rich in uranium and thorium resources, and has the technical capabilities to develop those resources. The development of uranium resources comes under both provincial and federal jurisdictions. Provincial Departments of Health are concerned about safeguards for people engaged in the mining industry. The federal government, however, exercises the major influence on the development of uranium. For example, the Atomic Energy Control Board licenses a company to undertake mining production, and is concerned with safeguards. Eldorado Nuclear Limited controls uranium ore refining in Canada. The federal government has stockpiled and traded uranium and by a statement of policy sets limits to the amount of foreign ownership in the industry. The sale of uranium and CANDU reactors to other countries comes under federal government control.

In the short term, there are no technical, resource, equipment, or materials supply constraints to the production and use of uranium. Improvements undoubtedly will take place in technologies of

mining and processing. Health and safety regulations also are receiving more attention. Production of uranium is well in excess of Canadian requirements. Exports are licensed only when a 30-year supply (at 80 per cent operating capacity) is evident for existing, committed and planned installations in Canada over the next decade. A statement of policy requires that utilities have contractual arrangements to ensure a 15-year supply for their needs.

Exports of uranium can make an increasing contribution to foreign earnings, at least for a number of years. By the year 2000, the value of exports might possibly reach one billion dollars (1977$). Opportunities to export without endangering Canadian supply can be appreciably increased if the thorium reactor is brought into commercial use, or if other breeder reactor technologies are adopted.

There are 24 identified uranium-bearing areas in Canada, widely dispersed across the country. Ontario at present accounts for nearly 60 per cent of Canada's recoverable resources (estimated on the basis of prices to $60/lb. of U_3O_8). Canada produced just over 20 per cent of world output in 1976.

The production estimates in Table 5-4 are approximately the maximum output obtainable, based on known resources and technologies, and assuming availability of manpower, equipment, capital financing and contracts. Exploration activities continue and have been successful in recent years in outlining additional orebodies. Of current output, about 9 per cent is required for nuclear generation in Canada. That proportion is expected to approach 20 per cent by 1985. Canada's future nuclear generating commitments as of 1976 were 11.9 GWe. The current commitments require 70 000 tonnes U for a 30-year supply and 25 900 tonnes U for 15-year contracts. This leaves an exportable surplus. Whether exports can be continued beyond 1990 or 2000 will depend upon the rate of nuclear power installations in Canada, the proving of additional uranium reserves and the timing of the commercial application of the thorium reactor.

Nuclear electrical generation as a principal contributor to an accelerated electrical option appears to be well supported by levels of uranium resources, in view of an export policy which seeks to ensure a 30-year forward commitment for the anticipated requirements in a 10-year period.

Renewable energy resources

Renewable energy resources have become, in the past two or three years, the subject of considerable discussion and assessment. Renewable resources are those resources which in principle are continually replenished, and not depleted by use. They

TABLE 5-4

Estimated Production of Uranium[1]

	U^2 (tonnes)	U_3O_8[2] (tons)
1976	4 850	6 300
1980	7 950	10 400
1985	12 500	16 300
1990	11 250	14 700

1 See also "1976 Assessment of Canada's Uranium Supply and Demand", p. 11, Report EP 77-3, and "Uranium Resource Evaluation", Report ER 77-1, Department of Energy, Mines and Resources, Ottawa, 1977.
2 1 tonne U equals 1 metric ton of elemental uranium, approximately equal to 1.3 short tons U_3O_8.

include, for example, solar power, hydro power, biomass (from plants and from animal wastes), wind and geothermal (probably not strictly "renewable", but apparently inexhaustible by man's conversion of it to energy). The term "renewables" as used here excludes conventional hydro power because it is already so well established as an energy source.

The objective in respect of renewable energy resources is to ensure that a full, systematic assessment is made of them to determine how quickly and to what extent they can make a substantial contribution to Canada's energy future. An indicative target for renewables taken together has been set at 5 per cent of Canada's primary energy requirements by the year 2000, and 10 per cent by 2025. These are very ambitious targets, equivalent, for example, to 400 000 barrels of oil per day in 2000 and about one million barrels a day in 2025. The 400 000 barrels a day in 2000 is equivalent to nearly one-quarter of all oil used in Canada today.

Resources such as solar power, wind and biomass are not new; they have been used through the ages of human existence. They are treated as new resources because of the widespread realization that most other resources are capable of being rapidly depleted, and because there is renewed interest in using them in very much greater amounts, driven by new technologies and management approaches, and as integral parts of the total energy

systems of advanced, industrial countries. The new uses of renewables are one of the most novel and exciting challenges facing Canada and other countries. If ways can be found to harness renewables economically and efficiently, the techniques can probably be spread rapidly to developing countries, and do much to ease their energy difficulties. It follows, too, that because of the relative ease with which at least some renewables can be introduced, they could be called upon as emergency and supplementary supplies if serious shortages of conventional energy resources begin to appear. This would be particularly true for solar power and biomass, including the conversion of wood into methanol and for the production of other gasoline substitutes.

Distinguishing characteristics

The following characteristics are more or less common to the renewables:

- They are renewable, but finite. For example, with solar power, wind and tides, their use today, as far as we know, does not significantly alter their future availability. Once developed as energy resources, they can continue indefinitely without depletion. However, <u>their total availability is limited</u>. Their use cannot be increased indefinitely but will reach finite limits. Hence, to sustain an economy or a society on renewable energy resources alone would require both a limitation of total energy use, and a complete adaptation of uses to the characteristics of the available renewable resources.

- They have a sufficient commercial potential as energy resources to justify substantial, immediate interest in them.

- Renewable resources are amenable to small-scale operations to meet local or individual circumstances; the feasibility of so using them in significant amounts remains to be demonstrated, as does their incorporation into large-scale energy systems.

- The renewables, for the most part, are not readily transported over long distances. Any use remote from production site would require conversion into another form -- e.g. electricity, or gaseous or liquid fuel. In the converted form, the renewables are more readily assimilated into established distribution systems and patterns of energy use.

- Basic technologies are at least partially developed. Considerable scope remains for additional technological improvements, and for bringing various elements of technology together into integrated systems.

- The renewable resources suffer from the lack of an existing operating system, and from the inertia and difficulties to change from the existing, proven systems.

- Managerial, organizational and support systems, financing provisions, manpower, equipment and supplies are only at the embryonic stage. No firm plans exist of how best to bring these essential components into coordinated, commercial operation.

- The economic viability of the renewables remains unknown though their potential viability will increase as the costs and prices of other energy resources increase. Market size is not known; costs, prices, competitive power are not known.

- The impacts and secondary effects arising from the large-scale use of renewable resources are not known; social acceptability is not known.

- Government policies, legislation and regulations, and the institutional arrangements to accommodate the new renewables are only beginning to be formulated.

- Repair and maintenance service requirements and costs are not known, and very few facilities exist at this time to carry them out.

- The adaptability and performance of renewables under Canadian climatic conditions requires a great deal of investigation.

The above list of distinguishing features makes two things clear. First, enough is known to suggest that the renewables hold promise and are technically feasible. Secondly, the entire development of the industries, their support and infrastructural requirements are at very early stages of development. That second factor suggests that extensive RDD&D (demonstration by test cases and deployment to achieve commercial impact) should be set in motion as soon as possible. The managerial and organizational processes will take many years to become fully established. There are many knowledge frontiers to cross, and entire systems to organize. If renewables, after three or four years, demonstrate potential as significant resources, priorities for their further development will then be able to be much better assessed.

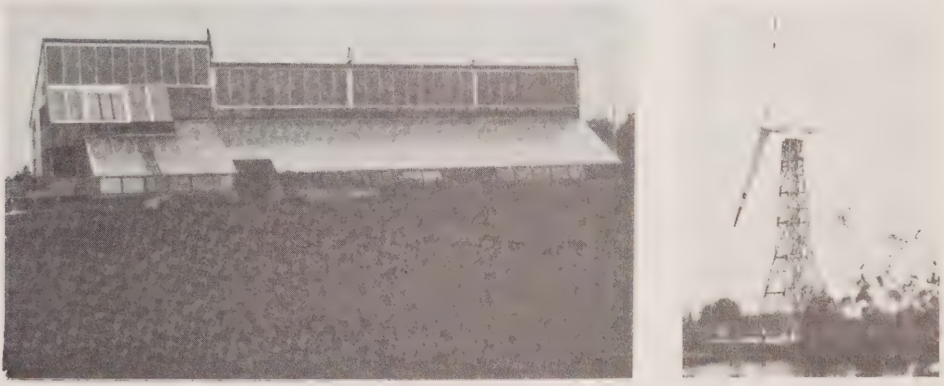
The first assessment task for renewables, therefore, is not to decide what quantities of energy each might deliver in 15 or 20 years, but how best to determine their feasibility and how to organize their commercial deployment. Many beginnings are being made on many parts of the renewables "universe". The federal Department of Energy, Mines and Resources has recently established a Renewable Energy and Conservation Branch to investigate the prospects more comprehensively and systematically, and many other interest groups are actively exploring the feasibility of one or another of the renewables.

Individual renewable resources

The renewable resources noted here are:

- hydro (non-conventional);
- solar;
- biomass (and urban and industrial wastes);
- wind; and
- geothermal.

No attempt is made here to assess the possible contribution of each renewable resource separately to Canada's energy supply in 2000 and 2025, but an allowance has been made for the renewables in total.



Learning to use renewable energy resources.

Non-conventional hydro power extends the use of hydro potential beyond the very substantial contribution of conventional river and lake hydro. The latter has been and will surely continue to be for the coming 50 years the dominant renewable energy resource. Traditional river and lake hydro power is now so well accepted as part of the energy system that it frequently is omitted in references to renewable resources.

The example of "conventional" hydro power might be a good one to use when assessing the "new renewables". How long will it be before solar power, for example, will have comparable management, organization, financing, market penetration, marshalling of manufacturing support industries, of labour force, repair and maintenance capability, and a record of proven performance to gain increasing acceptability? Although the large-scale application of individual renewables might not be practical or even preferable, nevertheless the renewables will be required to demonstrate a capacity to perform on a large scale as an integral part of the total energy system.

Tidal, wave, "low-head hydro" (smaller, local hydro sites), pumped hydro storage, ocean thermal differences and the related possibility of the production of hydrogen by electrolysis, are among the future, expanded uses of hydro power.

Solar power, the ultimate source of virtually all of the world's energy, stored or renewable, has, in recent years, attracted considerable renewed interest. The term "solar power" in the context of renewable energy usually refers to the marshalling of direct sun's rays for heat transfer or electricity generation. Two forms of solar power illustrate its potential uses within the long-term energy assessment. These are:

- the use of solar panels for heat transfer (both "active" and "passive"); and

- the use of solar radiation in a solar photovoltaic cell or similar device to produce electricity.

The second of these, electrical generation, shows less immediate promise of adding significantly to total energy supply, although its capability has been demonstrated in generating power for the space program and other uses. A third solar energy system, involving satellite collectors and transmission to earth, is not dealt with in this assessment, although some analysts hold out promise of an early and substantial contribution from that source.

Heat transfer for space or hot water heating has come to be regarded as the most promising, short-term application of solar power. It can be considered in two categories -- "passive" solar, such as window panes designed and situated to maximize heat collection when space heating is required, and "active" solar which makes use of collectors, heat transfer equipment, heat storage and heat exchange equipment. Relatively small units can be installed for individual dwellings and other buildings, or larger units can be used for district heating systems. Well designed, passive solar systems are considered by some experts to hold most promise for an early, significant contribution.

In some parts of Canada, an active solar system, if used in conjunction with a well-sited, well-built and insulated dwelling, with adequate heat storage capacity and heat transfer facilities, is estimated to be able to supply half, or something more than half, of the space and water heating requirements of the dwelling. However, at present, commercially supplied solar systems could entail a capital cost of $7,000 to $10,000 or more. Hence, the advantage of lower annual heating costs must be weighed by the user against the higher "front-end" capital cost of installing the system. For centralized systems, the advantages may be more pronounced. If solar heat is to deliver only one-half the requisite heat, some other energy source will be called upon to deliver the other half. The user, in effect, must install two heating systems, and some other supplier of fuel must stand ready, when called upon, to provide the additional fuel or power. If the other supplier is an electric utility, higher costs might be incurred to install and maintain generating capacity adequate to meet peak demands when solar systems are not filling the need. For solar power to make a significant contribution to energy supply, considerable re-design, retrofit, different siting of buildings, of communities and of energy systems would be called for.

The environmental impact and the social acceptability of solar installations would appear initially to pose no serious problem. However, there is no assurance that this is so. The question of "right to light" has been raised. Will the installation (or possible future installation) of a solar system carry with it a guarantee that there will be no future interference with the solar impact? Such interference might come, for example, from the construction of a high building or from a neighbour's trees. Moreover, there is no assurance that extensive solar installations will have no effect on atmospheric conditions, possibly altering local wind, temperature, moisture and other climatic characteristics.

Biomass, as an energy resource, involves the consumption or transformation of biological products into energy. Two sources of materials are most commonly referred to:

- agricultural produce or waste; and

- forest products or waste.

A third source -- peat -- usually is treated as a separate source of energy.

For forest and agricultural produce, both waste materials and dedicated stands and crops can be included. In the latter case, some part of agricultural and forest production would be grown and harvested specifically for use as biomass energy. Peat can be harvested, dried and burned as an additional form of biomass energy, and is so used in a number of countries. Another source

of material -- urban garbage -- has similar characteristics in conversion and use to biomass materials. The combustible materials of urban wastes are burned under controlled conditions to produce heat which can be used for steam heating systems or thermal generation of electricity, or co-generation of both.

A significant amount of biomass energy (wood burning, for example) already is being used, although that use is not generally included in statistics on energy consumption because it does not pass through the usual commercial channels. A much greater amount of biomass energy can be produced from materials not now so used commercially (although some are alternatively used in agriculture, for animal care, or on the land, or for local fuel uses). Two forms of use are generally referred to: direct combustion of materials to produce heat and steam; conversion of materials into liquid or gaseous fuels, for example, methane, methanol or to other gasoline substitutes.

A significant expansion of the use of biomass materials is possible fairly quickly because of a number of advantages which biomass has in comparison with most of the other new renewables:

- it has had continual use as a source of energy;

- simple technologies for its use are known and have long been applied; and

- biomass is a fairly easy "add-on" to existing industrial activities (agriculture, forest products, chemicals) so that management, financing, equipment, supplies and labour force requirements can be organized within existing institutions.

Examples of the ease with which biomass can be introduced are not hard to find -- the burning of forest slashings and wood wastes (hog fuel) by sawmills, the manufacture of methanol, methane or other gasoline substitutes from manure or from wood, the burning of urban waste to generate steam for heating and electricity, the direct use of wood (especially with new stove and furnace designs) for home heating in rural areas.

The principal constraint to a much increased use of biomass has been economic -- it was just not worthwhile in an era of low-cost oil and natural gas. Per unit of weight or bulk, biomass materials tend to have relatively low thermal values so that use or conversion near the site of origin is favoured. There are sizeable "materials-handling" impediments. Energy and manpower requirements are relatively high per unit of recovered energy. However, not dissimilar considerations apply to strip mining for coal or the recovery of oil from the oil sands. Capital intensity is relatively low, but labour input requirements are relatively high in comparison with most conventional energy resources. The historical development of industries geared to other energy forms creates inertia and logistical difficulties to change.

Undoubtedly, significant technological improvements can be made, following research and testing, in the mechanized collection, transportation and handling of biomass materials, in the production of energy from them, and in the use of that energy. Improvements could likewise be made in organization, management and financing. Although the economic viability of various biomass operations remains to be demonstrated, the increasing cost of oil and of other conventional forms of energy does much to ensure that more significant operations will be possible. Assessments of biomass potential usually rate it as substantial, and capable of early exploitation.

One evaluative technique is to examine the potential sources of biomass in terms of the energy needs of that source. For example, what could agricultural biomass contribute to the energy needs of the farm, or forest biomass to the energy needs of the forest industries? What could city waste contribute to the energy needs of the city? In establishing the commercial viability of any source of biomass there is no reason to so confine it. However, further close assessment is required of the biomass potential, the problems, the possible solutions, and the probable delays which would be encountered in bringing projects to commercial fruition.

Wind power has long been harnessed as a source of energy. Recently, advanced equipment and systems have been developed, and are being improved, to increase significantly the contribution of wind power to the total energy system. Like solar power, wind is a widely dispersed, unconcentrated form of energy, irregular and interruptible in its concentration. The principle of its use is to localize and stabilize a concentration (or a magnification) of that power. Also like solar power, two approaches are being tested: the first is by means of small, individual units to serve separate dwellings or other buildings; the other is in concentrated banks or "farms" of wind turbines from which the power can be drawn into district or network electrical grids. Installations might be especially useful in remote, windy locations where other power sources are difficult or expensive to provide. Sites in northern Canada and in rural areas are examples.

Two methods of using wind power also exist. The first is to achieve direct mechanical conversion, as was done by the old windmills to pump or to move wheels and gears. One significant potential use of this mechanical conversion would be to lift water into storage basins for hydroelectric generation. Another use would be the conventional pumping of water, for example, for irrigation purposes.

The second and most researched method of using wind power is for electrical generation. Technological improvements have been made, and undoubtedly will continue to be made, in the efficiency of generating systems. As with solar energy, the variations in

Wind power?

"The Pickering nuclear power generating plant of 2 000 Mw capacity would have to be replaced by 60 000 windmills built on a four-mile wide strip of land reaching from Toronto past Kingston. The technical, economic, financial and environmental implications of such a project are beyond imagination."

-(Legacy, Environment Ontario newsletter, as quoted in the Ottawa Citizen, April 19, 1978).

concentration from time to time make it difficult to use wind power as a sole energy source unless the use itself is interruptible or storage capabilities exist to carry over the low periods. Otherwise, a back-up or dual power sourcing provision is necessary. One approach is a two-way flow in which power from the wind turbines flows into an electricity grid when wind conditions enable power generation to take place, and power flows back into the local system when wind conditions do not make the unit self-sufficient. There are difficulties to overcome in applying the two-way flow technique, one of which is the underutilization of the other electrical generating capacity when wind power is available.

As with solar power, the institutional and organizational arrangements are not in place to deliver large quantities of energy on a sustained, commercial basis. Considerable further technological development is also likely to occur before that state is reached.

Geothermal energy is that stored within the earth in the form of heat, usually accessible as hot water or steam. Its presence is apparent in hot springs and geysers as well as in volcanoes. Certain locations on the earth's surface offer more ready access to geothermal energy than others. Only a few sites in Canada, mostly in the Rocky Mountain area, appear to have some local, commercial possiblities. More ambitious projects to tap the internal heat of the earth would involve deep well drilling

(10 000 feet or more), using underground water, or pumped water to produce in situ steam or hot water which could then be brought to the surface for use. Unfortunately, the water may be high in pollutants such as salts, and its disposal, therefore, might require careful waste management.

Geothermal

"California has a vast and thus far unused source of power on tap in the geysers of Sonoma County. Tests have recently been completed that show the tremendous possibilities in the use of the geysers for the purpose of power development."

-Scientific American, June 1925.

Geothermal energy has its most apparent use at or near the site of its recovery. There are many uncertainties and difficulties standing in the way of its use, although local uses are being made on a significant scale in some countries of the more readily accessible sites. As a significant energy source, geothermal energy appears to be more distant in time than the other renewable resources referred to above.

Energy contribution of the renewables

Apart from noting the energy potential that exists in the various renewable resources, little can be said at this time about their future contribution to delivered energy, either in terms of its timing or its amount. Considerable emphasis is required on researching, testing and proving each of the renewable resources. Each of the renewables and the renewables as a group illustrate the need for a comprehensive, coordinated, "systems" approach to energy resources. Every feature -- siting, technology, management, manpower, equipment and supplies, financing, environmental concerns, repair and maintenance, legislation, regulation and institutions, federal/provincial agreement, economic feasibility, social acceptance, provincial differences, costing and pricing, ownership and control, secondary effects, integration into other

energy supply and demand patterns -- require thorough investigation. Many more demonstration projects will be necessary before a significant commercial deployment can be evaluated.

For purposes of this long-term energy assessment, the contribution assigned to the renewable resources in total (excluding conventional hydro) is equivalent to 5 per cent of the illustrated energy needs by 2000 (amounting to 0.8 quads of energy); and 10 per cent by 2025 (amounting to 2 quads of energy). Those are substantial amounts of energy and represent a very ambitious program in so short a time by a combination of resources which are only beginning to have a commercial impact. The greatest areas of uncertainty are the market attractiveness, and the institutional, organizational and management deficiencies which will have to be overcome once the economic feasibility and public acceptance of the new energy forms have been demonstrated. Only a major supply crisis in other forms of energy likely would permit these impressive obstacles to be overcome, in substantial degree, before 1990 or 2000.

Consolidated energy supply program

The above accounting of energy resources has dealt principally with the physical availability and, to some extent, the technical capability of producing the individual energy resources. The assessment concludes that a substantial supply potential exists from a variety of resources. However, the existence of a potential in no way assures that an adequate supply of any combination of the energy resources will be available, year after year, over the 50-year span. The potential supplies from various resources are not added to a total potential supply because they are unlikely, in practice, to be fully additive -- i.e. there likely is no way that all supply options can be developed on an "all-out" basis at the same time. Any satisfactory combination of the supply potentials to meet Canada's growing energy requirements will be difficult in the extreme. Some supply combinations might be competitive in a way which does not contribute to a well integrated system. Careful integration and management will be required to eliminate unnecessary conflicts and inefficiencies.

The assessment in this chapter considers which combinations of resources are most probable or most appropriate for maintaining satisfactory, sustainable energy balances beyond 1990. By that time, recourse to the present "fall-back" of importing more oil will not be an acceptable, or perhaps even an available option. Chapter 6 examines the energy demand/supply balances, and Part III of the report outlines the processes of adjustment by which an adequate, sustainable supply of energy might be made available.

The recommended programs in Chapter 13 contain an outline for a Consolidated Energy Supply Program which calls for progressive

integration of supply opportunities as each possibility is successively proven. The Consolidated Energy Supply Program seeks to make maximum use, as economically feasible, of the indigenous supplies of each province or region and to supplement those, in the energy-deficient regions, by Canadian resources. Another important element of the supply strategy is to increase the market for natural gas in central and eastern Canada, and the Consolidated Energy Supply Program illustrates some of the related supply implications of an expanded natural gas program.

6. ACHIEVING A SUSTAINABLE ENERGY BALANCE

Chapter guide

- *Moderations in the rate of growth in demand can contribute at least one-half of the adjustment which will be necessary to achieve satisfactory energy balances by 2000 and to 2025.*

- *Very difficult changes are needed in the pattern of demand. About one-half of the demand for oil would be switched to other energy resources.*

- *Energy supplies from domestic sources might be just adequate to meet the moderated demands by 2000. From then to 2025, satisfactory demand-supply balances should prove to be more readily sustainable in a continually dynamic relationship of changing patterns of energy demand and supply.*

- *The energy supplies would be sufficient to support higher incomes for Canadians arising from taking advantage of new economic opportunities including, for example, exploiting export opportunities for energy-intensive goods and services, and the sale abroad of Canadian technology, skills and management systems.*

- *The first objective in the evolving energy balances is to replace imported oil with Canadian energy resources. That objective might not always be consistent with the objective of maximizing energy efficiency, but can be based on sound economic relationships.*

- *As soon as possible, oil should be essentially eliminated from space heating, from about one-half of its industrial uses, and from 25 per cent or more of transportation uses.*

- *Each province or region, particularly in central and eastern Canada, can strive to achieve a maximum degree of dependence on its own indigenous resources, possibly at least one-third of its energy requirements. Any remaining energy deficit in that province or region would be met by Canadian energy resources -- a "Canadian reliant" system would be established.*

- *To achieve satisfactory energy balances will require the full participation of all Canadians -- energy suppliers and users, the provincial, municipal and federal governments and the public at large.*

Chapter 6. ACHIEVING A SUSTAINABLE ENERGY BALANCE

Canada's national advantage in energy in the future will be achieved by the dynamic balancing of changing energy demands and supplies. The policy objectives are to ensure that these energy balances at all times serve the economic and social aspirations of Canadians, and that satisfactory energy balances, although continually changing, are sustainable. In the past, an almost unlimited energy supply could be maintained by importing, as required, low-cost oil. From now on, and particularly beyond 1985, that option will not be present. Substantial adjustments to demand will be necessary under severely constrained, perhaps disruptive, conditions.

Among the principal determinants of satisfactory energy balances are:

- the skill with which energy demands are tempered;

- the innovative approaches to potential energy supplies;

- a concerted effort to define and pursue long-term objectives by implementing much different management approaches to the energy system;

- the ingenuity applied to interfuel substitution -- a matching of demand and supply adjustments;

- the application of greatly enhanced research, development, technological innovation and the deployment of new energy opportunities through the modified marketplace;

- the public's response to the choices signalled by higher energy prices, by price differentials, and by other incentives and disincentives;

- the positive leadership of business and governments to bring forward satisfactory energy programs;

- the successful coordination of industrial, provincial and federal priorities into a national energy system;

- Canada's participation and response to world energy developments and to international opportunities;

- the contributions to balances made by enhancing our capacity to store and transmit energy; and

- adjustments to ensure economic and environmental feasibility, and public support.

These determinants are brought together in a complex, dynamic process. The critical considerations are not the physical resource capabilities, but the human dimension -- the economic attractiveness of the necessary adjustments, the processes of organization and management, the application of effort, skills and ingenuity, and a constructive, public response to the challenges and to the need to adjust. Within that process of adjustment, responses to prices and price differentials hold the key. These responses are made by Canadians in the marketplace; by governments in their policy actions, and by industry in its management decisions. However, price signals alone are likely to be inadequate to direct the massive transitions which are required, and to do so with sufficient lead time. The design and implementation of a comprehensive adjustment process is required. (See Part III.) As noted in Chapter 1, the adjustment process can be viewed as a comprehensive, integrated National Energy Program in which long-term objectives and targets focus the actions of participants from industry, governments and the public. The National Energy Program is, in effect, a recognition of the need for a concerted, national drive to achieve satisfactory, long-term energy balances, to deal effectively with that third dimension of time -- the long-term future.

What does "satisfactory energy balances" mean?

Energy balances are dynamic relationships between the many forms of energy supply and their many uses. At any point in time, allowing for changes in stored energy and international trade in energy resources, supply and demand must balance -- we can't use more energy than we have. We can produce more energy resources than we currently use, but the excess, for a time, enters into storage or is exported. Thus, some kind of balance is always maintained. That balance could become highly unsatisfactory in terms of the economic needs or reasonable social aspirations of Canadians. The balance could deteriorate to a position where it caused great economic hardship and social disruption. If the demands for energy tend to outrun supply, or there are mis-matches between demand and supply, allocations, rationing and other forms of controls will be necessary. Under those circumstances, an unsatisfactory degree of energy determinism would occur. Economic well-being and personal and social aspirations would no longer be adequately served by the energy system but would be controlled by it.

Under conditions of constrained, or high-cost supply, the balancing process produces pressures to reduce demand and to increase supply. The process is like pushing together two arms of a V made of spring steel. The farther each arm has to be pushed, the greater is the strain. If demand reductions are

pushed too far, severe strains develop on the demand side. If attempts are made to increase supply beyond some readily available amount, severe strains develop on the supply side. (See Chapter 4, Figure 4-1.) Several combinations might result in satisfactory equilibrium positions. To establish the probable range within which satisfactory positions lay is a principal task of a long-term assessment.

The trend in primary energy since 1975 has been generally in line with the direction called for in this report. The rate of increase in consumption for 1976 and 1977 averaged about 3.1 per cent; the share of oil declined, principally offset by an increase in the use of nuclear power. Imports of oil and products were down to about 725 thousand barrels per day from 859 Mbpd in 1975, and from 1 020 Mbpd in 1973. Exports declined more rapidly, from 1 387 Mbpd in 1973 to nearly 900 in 1975, to about 530 Mbpd in 1977. However, too much should not be read into these changes in terms of developing trends. In particular, economic performance was well below the pace necessary for satisfactory maintenance of incomes and employment. Improved economic performance and some short-term reductions in the international real price of oil could again alter the rate of growth in energy consumption, and the use of oil, in ways contrary to the above short-term direction. For that reason, even greater efforts of conservation and of substitution away from imported oil remain critically important.

Adjusting energy demand

The indicative target for a lower rate of growth in demand, as described in Chapter 4, is for an average rate of increase of 2.8 per cent a year in primary energy demand from 1975 to 2000, compared with a rate of about 5.3 per cent from 1960 to 1975. The target for the years 2000 to 2025 in an average growth rate of 0.9 per cent a year. These are, by historical standards, very substantial reductions, and will require immense efforts of energy conservation, increased efficiency and structural changes in the economy.

However, lower rates of growth in energy demand are not the only requirement. To achieve satisfactory energy balances, another essential requirement is <u>to alter patterns of use to the energy which we can have in 20 or 25 years' time, not just reduce demand for the energy resources which we have been accustomed to use in the past</u>. This substitution process is likely to be even more difficult, especially between now and 2000, than the achievement of lower rates of growth in demand. Some moderations in demand can be made fairly easily through elimination of the most readily reducible wastes and inefficiencies. Careless overheating or overlighting are examples; lack of adequate building insulation and inefficient car performance are others.

Energy waste in industry is another. As energy costs increase, measures to reduce energy consumption become economically attractive. However, at some point, the magnitudes of the requisite demand reductions can become so great, or take on such new forms, that they represent fundamental changes in lifestyles. These changes might be satisfactory or, for many years, they might involve a deterioration in individual and community well-being -- a deterioration which might be avoided by adequate, long-term planning and preparation.

Often, the lifestyle changes mean giving up one demand entirely and substituting another. For example, commuting into large cities by automobile would be willingly given up by an increasing number of people if a first-class rapid transit service provided the public with a better alternative. Energy efficiencies and energy substitutions also have to be carefully examined. Car pool arrangements might be more energy efficient than a massive public transit system. However, the transit system would permit greater substitution of electricity for oil and that might become a more dominant consideration. In time, too, different patterns of habitation and work can greatly reduce per capita energy requirements such as those caused by inefficient commuting arrangements.

Increased efficiency in the accepted way of doing things will make a valuable contribution to moderation of demand. However, the short-term changes might delay more fundamental adjustments. For example, increased efficiency in automobile performance (more miles per gallon) might encourage, for a time, more rather than less single-passenger automotive commuting. The needs of the longer adjustment process must be considered at the same time, for example, the development of electricity-powered vehicles or transit systems. Another illustration is given by the trucking industry. Immediate increases in fuel economy are an advantage, but might delay, for a time, greater rationalization of the trucking industry which would make greater fuel savings. To effect rationalization, changes in trucking regulations and corporate ownership or operations probably will be necessary to reduce low-load haulages and empty return trips. The avoidance of higher energy costs by conservation and greater efficiency also affects discretionary income. For example, a significant saving in gasoline might be achieved if car performance is increased from 20 to 40 miles per gallon (if people do not offset it by driving more miles). However, this "saving" might lead to other energy intensive demands, for example, motor boats, snowmobiles and air travel.

Satisfactory energy balances, therefore, are complex, ever-changing relationships, heavily dependent upon adjustments to energy demand. In times of rapidly rising energy prices or growing constraints on supply, a choice arises: either take action well in advance to smooth out the adjustments, or meet the

ensuing disruptions with controls, allocations and other discomforts. Advance preparation is more difficult but far more satisfactory. Advance action does not require central planning and control, but it does require a large measure of agreement on what actions are required, and when, in order to forestall serious trouble. Advance preparation also requires a good deal of flexibility in approach and of resiliency to recover from unforeseen delays, setbacks and offsetting developments. One form of resiliency is to have a margin of reserve in energy supplies. Another aid to resiliency is continual, systematic reassessment of the present position and of the immediate and the long-term outlook to see whether the original targets are still appropriate, and whether progress is being made at a satisfactory pace to avoid an impending crisis.

Energy supply — Is there enough?

An illustration was given in Chapter 4 of the magnitude of the total energy requirements which might emerge over the coming 25 and 50 years. The illustrative primary energy needs were as follows:

	1975	2000	2025
		(quads)	
Primary energy requirements	8	16	20
Less "renewables" supply	-	0.8	2
Supply required from conventional energy resources	8	15.2	18

Although the increases in energy demand are substantial, especially between 1975 and 2000, the requirements reflect much lower rates of growth in demand than in the past 25 years. Some analysts call for even sharper reductions in demand, and express the view that a much lower use of energy would support satisfactory, but significantly different, personal and social achievement. This present assessment supports the objectives of even further reductions in energy demand, but also recognizes that, for many individual and social aspirations, higher rates of growth in the use of energy would be required. These would support rising incomes, greater freedom over the use of time, and more assistance to the less fortunate people in Canada and abroad. In addition, Canada is expected to be in a favourable position to pursue more dynamic industrial and trade options if that becomes an accepted course. The magnitude of the transitions themselves require the support of dynamic, expansive economic activity to finance them and to ease the problems of manpower, equipment and resource reallocation. The rates of increase in

energy demand which are used here are considered to be as low as practical to effect reasonably satisfactory, if substantially different, patterns of energy use, and to meet conditions of higher energy cost and restricted supply. These lower rates of growth will require substantial changes in society if satisfactory levels of personal income and well-being are to be achieved. Other patterns of adjustment can be postulated, but the magnitudes of the adjustment process, and the difficulties of adjustment are not likely to be much reduced.

Is there an energy supply potential sufficient to sustain even these reduced rates of increase in energy demand? Chapter 5 contained illustrations of high supply potentials for the principal energy resources. These were regarded as perhaps individually achievable but, for the most part, only under conditions of severe pressure. In total, the financing, the equipment and supplies, the labour force, the supporting institutions and infrastructure, the environmental requirements, the necessary government policies, the public acceptance, and the sheer burden or organization and management would pose immense difficulties.

Apart from the increase in hydro, nuclear and coal generation of electricity, most of the energy would come from new sources either not yet proven to exist or not proven to be technologically or commercially feasible. In addition, the share of oil in total use is cut very drastically, and the share of other resources, especially electricity, increased accordingly -- a very difficult substitution to make. Even then, the oil supply would be pushed hard to achieve the additional production here indicated. As early as the year 2000, the oil would come almost entirely from new sources -- probably heavy oils and oil sands, but perhaps also from frontier areas and enhanced recovery in existing producing areas. The additional natural gas supply might well be less difficult to achieve than the oil, but it, too, would be extended into new, unknown sources of supply and into additional markets.

The subtantial increase in the share of electricity is essential to satisfactory energy balances. Increased generation from hydro and coal is accompanied by a substantial increase in nuclear generation. Co-generation, by product energy and renewable resources also are expected to be used for electricity generation. The increasing reliance on electricity is because of its proven capability to supply substantial, additional amounts of energy. Especially during times of such massive transformation in energy systems, we must initially plan to use the energy we know that we can have. If, for example, renewable resources demonstrate over the next few years a much greater capacity to penetrate energy markets, their further expansion would perhaps moderate somewhat the use of nuclear power in electricity generation. At present, however, no such greater allowance seems

practical. Nor would it materially alter the main patterns of energy transformation. For renewable resources, an entirely new industrial capability needs to be brought into place under very difficult conditions.

Thus, only for electricity does the potential supply appear fairly readily obtainable. All three of the major resources (hydro, coal and uranium) have substantial potential for increased electrical generation. In addition, a number of the renewables and "other" resources (co-generation, waste heat, new forms of hydro power, etc.) can be used to generate electricity.

Changing shares in energy supply

Table 6-1 shows the amounts of primary energy which would be supplied by oil, natural gas and electricity in 2000 and 2025 if the shares of each remained as they were in 1975. Because of the high requirements which this places on oil, it is referred to here as an "option we probably do not have".

If the shares of energy supply were retained as shown in Table 6-1, about 3.7 million barrels per day (MMbpd) of oil would be required in the year 2000, and 4.6 MMbpd in 2025. The supply potential in Chapter 5 indicated that, by pushing domestic production as much as seems at all practical, there might be about 2.5 MMbpd available in 2000, and possibly 3.7 MMbpd by 2025. The shortfall of one million barrels per day in 2000 is particuarly serious, especially since the 2.5 MMbpd domestic production target will be difficult to achieve. Reliance on imports to make up the oil deficit is to be avoided if at all possible, because of the precarious world oil situation which is expected to exist at that time. The present target of the federal government is to limit imports to not more than 800 000 barrels per day by 1985. This assessment calls for a reduction to 400 000 barrels per day by 2000.

If energy supply and demand can be brought into balance by the year 2000 with the reduced reliance on oil, that level of production and use is probably sustainable to 2025 and beyond. Thus, oil does not "disappear" from use after 2000, but reaches a sustainable level which, for many years, might be higher than current production in Canada. The greatest difficulty is likely to be from now until the year 2000.

To overcome the difficulties associated with oil, a different pattern of supply is illustrated in Table 6-2 -- only one of many which could alleviate the restricted oil supply situation. Here, the requirements placed on oil amount to about 2.5 million barrels per day in 2000 and in 2025 -- a reduction of more than one million barrels per day by the year 2000 from that shown in Table 6-1. The principal offsetting change is the substantial increase in electricity, but the introduction of renewable resources also

TABLE 6-1

An option we probably do not have --
Maintaining oil, gas and electricity shares
of supply as in 1975

	per cent	1975 quads	2000 quads	2025 quads
Oil	46	3.7	7.4	9.2
Natural gas	19	1.5	3.0	3.8
Electricity	35	2.8	5.6	7.0
Total	100	8.0	16.0	20.0

makes a significant contribution. By 2000, electricity would by supplying almost one-half of Canada's total energy requirements, allowing for the fact that some part of the energy from the renewable and byproduct resources and from co-generation would be for electricity generation. When a similar allowance is made in 2025, electricity would be supplying even a higher share of the total, as shown in Table 6-2 and in Figure 6-1.

Oil and natural gas

The increased production in Canada would require that oil be extracted and processed from the oil sands and heavy oil deposits in large quantities. Nine or ten additional oil sands plants would be required beyond the three now operating or planned. It is expected that one or two of these would use in situ methods, not yet demonstrated as commercially feasible. Heavy oil production would be substantially increased and processing facilities for heavy oil would be established in Canada. Part of the heavy oil/oil sands program might be replaced by new oil discoveries in conventional areas, enhanced recovery from existing fields and by production from frontier areas, but perhaps with not much less cost or difficulty than developing the heavy oils and oil sands.

As noted in Chapter 5, the increased production of natural gas, to drive another gas "wedge" into the market, based on assured supplies, is an important element of the supply strategy. The increased supplies so required will call for intensive efforts, through time, in all of the potential gas producing areas.

TABLE 6-2

Changing patterns of energy supply - 2000, 2025

	2000		2025	
	quads	per cent	quads	per cent
Oil	4.8	30	5.0	25
Natural gas	3.2	20	3.6	18
Electricity	7.2	45	9.4	47
Renewables[1]	0.8	5	2.0	10
Total	16	100	20	100

1 About one-half of the renewables are assumed to be used for electricity but are not included in the electricity shares shown in the table.

Electricity

The increased share of electricity will also be difficult to achieve, particularly between now and the year 2000, not because of supply constraints (except perhaps financial), but because of difficulties to bring about substitutions on the demand side. From a practical point of view, there is considerable difficulty in changing patterns of demand rapidly away from oil and to electricity.

Although the required installed electrical capacities for 2000 and 2025, shown in Table 6-3, represent significant increases from current levels, they are well below the potential shown in Chapter 5. The annual rate of increase in installed capacity is just over 5 per cent a year between 1975 and 2000, and just over 1 per cent a year from 2000 to 2025. The latter rate might prove to be far too low, but no difficulty should be encountered beyond 2000 in maintaining a higher rate of capacity installation. In fact, greater economic stress might result if too rapid a decline in capital expenditures took place at that time. A somewhat higher rate of installation than the 5 per cent annual average might occur to 1985. <u>No slowing down of installation of additional electrical generating capacity is justified at this time on the basis of this longer term assessment</u>. The pace of installation of capacity is a decision that is made within the total assessment by each utility and each provincial government, taking into account a broad range of considerations.

Figure 6-1 and Table 6-3 illustrate the full array of changes in one of many combinations which could satisfactorily balance the patterns of demand in 2000 and 2025. No allowance is made for exports or imports of energy resources. It is assumed, as noted in Chapter 3, that Canada maintains considerable international trade in energy resources working toward a possible export surplus.

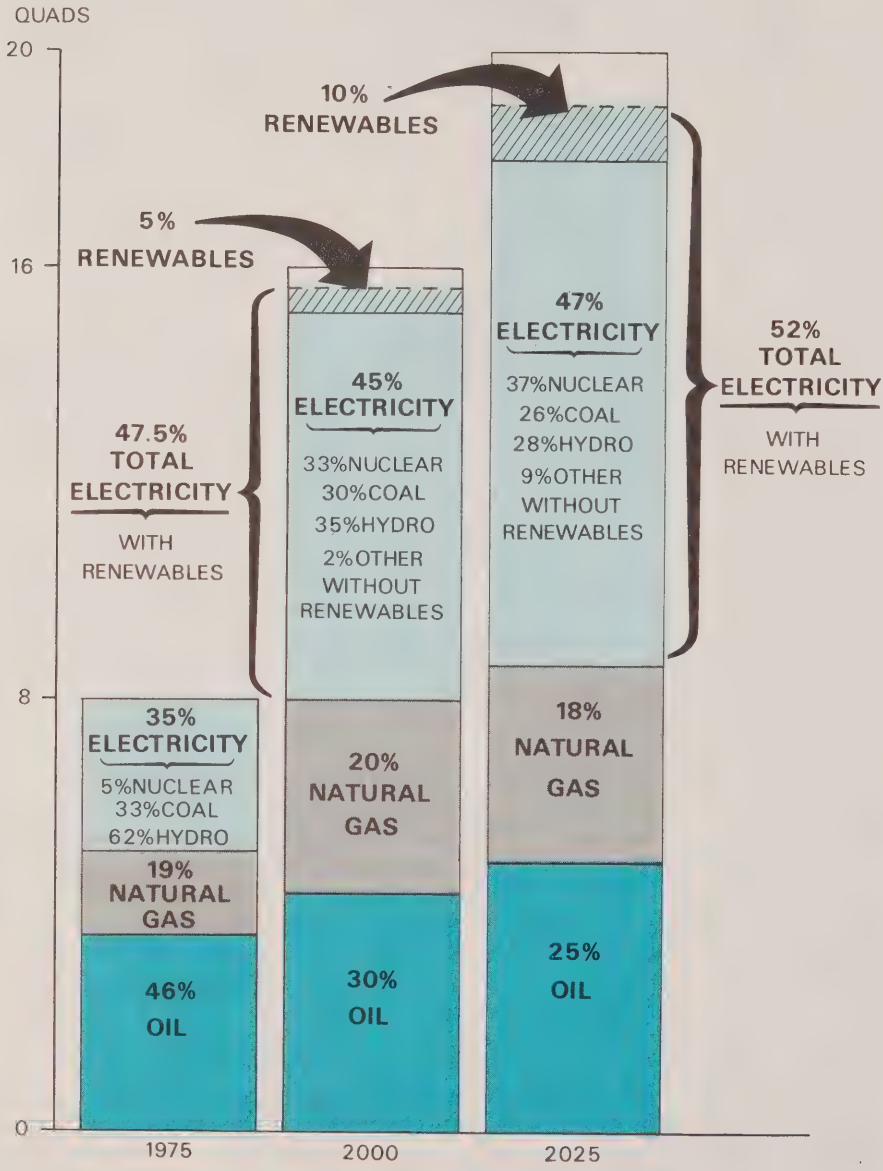


Figure 6-1. Changing patterns of energy supply, 1975, 2000, 2025.

TABLE 6-3

Changing patterns of energy supply - 1975 to 2025

	1975 [1]	1990[1]	2000	2025	Increase 1975-2025 (%/year)
Oil ('000 bbls/day)	1 780	1 680	2 400	2 500	0.7
Natural gas (billion cubic feet/year)	2 500	4 190	3 200	3 600	0.7
Coal (million tons)[2]	30	112	120	200	3.7
Renewables ('000 bbls/ day oil equivalent)[3]	-	-	400	1 000	-
Electricity (GWe)[4]	60	152	210	275	3.1

1 "An Energy Strategy for Canada, Policies for Self-Reliance", Department of Energy, Mines and Resources, Ottawa, 1976, p. 81; the "high-price" scenario -- Canadian energy supplies based on the 1976 level of international oil prices; data rounded.

2 In 1975 and 1990, essentially all for thermal-electrical generation; in 2000 and 2025, an allowance is made for other energy uses of coal.

3 Does not include conventional hydro power or, for 1975, renewables which are used but not typically included in energy supply accounts.

4 Generating capacity, including hydro, nuclear, coal and other resources.

The following features of Table 6-3 merit particular note.

- Oil production increases to 2000, and is maintained at a sustainable level; however, oil provides a much lower share of Canada's total energy than at present.

- The production of natural gas increases to 2000 and again to 2025. (The higher 1990 estimate included a greater allowance for new discoveries which, if they occur, will raise the gas supply potential.) A further increase in natural gas production from 1975 to 2000 and to 2025 would make a most important contribution to a satisfactory energy balance.

- Very substantial increases are shown for coal production, not all of it for thermal-electrical generation.

- The renewable energy resources emerge by 2000 as supplying the energy equivalent of nearly one-quarter of that now supplied by oil, and as supplying more than one-half that equivalence in 2025. Looked at another way, the renewable resources, in the next 22 years, would achieve electricity production capability about four times greater than nuclear power has achieved in the past 30 years -- no small accomplishment, particularly since only one-half of renewable resources are assumed to be used for the generation of electricity.

- Electrical generating capacity increases substantially, although the rate of increase is much lower than in the past 20 years. A major difficulty will be to ensure a fairly even rate of growth so as to avoid a serious bunching of plant construction or periods of inadequate capacity.

- Each of the supply requirements and the interfuel substitutions of Table 6-3 are very difficult to achieve. Taken together (or in any other combination), they require extraordinary adjustment and implementation.

In Table 6-4, all three of the basic resources for electrical generation are shown as increasing substantially. By the year 2000, most conventional hydro sites, even in remote areas, are assumed to be developed. The physical quantities of coal used for electrical generation increase by a very large amount, moderated by production and environmental constraints, other uses of coal, and competition from nuclear power. Nuclear electricity generation shows the most pronounced increase. Beyond 2000, nuclear replaces hydro power as the largest single source of electricity. Before 2025, the thorium fuel cycle or a variant of a breeder fuel cycle is assumed to come into use to ease the pressures on uranium supply.

TABLE 6-4

Changes in electricity generation

	1975		2000		2025	
	GWe	per cent	GWe	per cent	GWe	per cent
Hydro	37	62	69	33	72	26
Coal[1]	20	34	61	29	69	25
Nuclear	3	4	67	32	99	36
Renewables (and other)			13	6	35	13
Total	60	100	210	100	275	100

[1] In 1975, also oil and gas.

Renewable and other resources (particularly biomass, solar, wind, tidal, low-head hydro, but also including peat and urban waste, and, by 2025, possibly wave) are assumed to be used for electrical generation to an increasing extent. By the year 2000, they would be called upon to supply perhaps four times as much electricity as supplied in 1975 by nuclear power -- another measure of the immense organizational and management achievements which will have to be undertaken very soon for renewables. By 2025, the amount of electricity generated from renewable resources would exceed that now produced from coal, oil, natural gas and nuclear.

Potential imbalance of demand and supply

The available energy supply outlined above would provide the total energy needed in 2000 and 2025, but the patterns of demand and supply by type of resource would not necessarily match. To bring about a satisfactory balance, the use of energy would have to change to permit substitution of electricity for oil (unless, of course, more oil became available than is assumed to be probable). The changing supply shares are illustrated later in Figure 6-3. Figure 6-2 illustrates the kind of mismatching which could occur, and shows particularly the oil shortfall. It illustrates the magnitude of the substitution which would be required.

The increasing amounts of oil which will be required by the industrial and transportation sectors increase the substitution difficulties. In the long run, however, efforts to substitute other forms of energy for oil must eventually settle on the

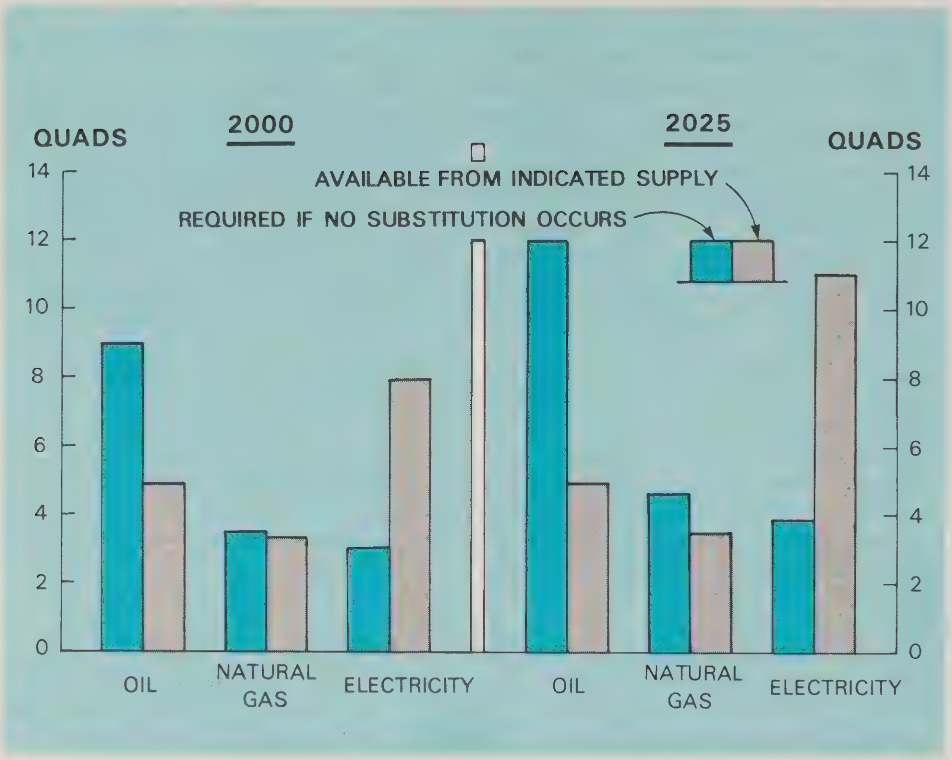


Figure 6-2. Illustrative need for interfuels substitutions, 2000, 2025.

industrial and transportation sectors. In the meantime, as noted below, virtually all oil is assumed to be eliminated from space heating (mostly, the residential and commercial sectors).

The near-balance for natural gas simply indicates that efforts to increase gas supply should be pushed hard, especially since natural gas could substitute further for oil and, thus, ease the potential shortfall in oil supply. It is important to recognize throughout the report that a stable relationship does not mean that no pressures of adjustment are present. To maintain even a constant share can be an extremely difficult undertaking.

The capability of electricity to move into the energy market is illustrated. Even greater substitution of electricity could be made if patterns of demand could be further changed to accommodate more electricity. However, even the illustrated substitution of electricity, for oil, directly or indirectly, will be difficult, especially between now and the year 2000. The addition of renewable energy resources to Figure 6-2 would not reduce the magnitude of the substitution problem.

Accommodating necessary substitutions

Given the above discrepancies in patterns of supply and demand, some combination of four adjustments are necessary to obtain a satisfactory balance:

- reduce further the demand for energy (in particular, oil);

- find and produce more oil and natural gas in Canada;

- increase the efforts to substitute more electricity, natural gas, renewables and byproduct energy for oil; and

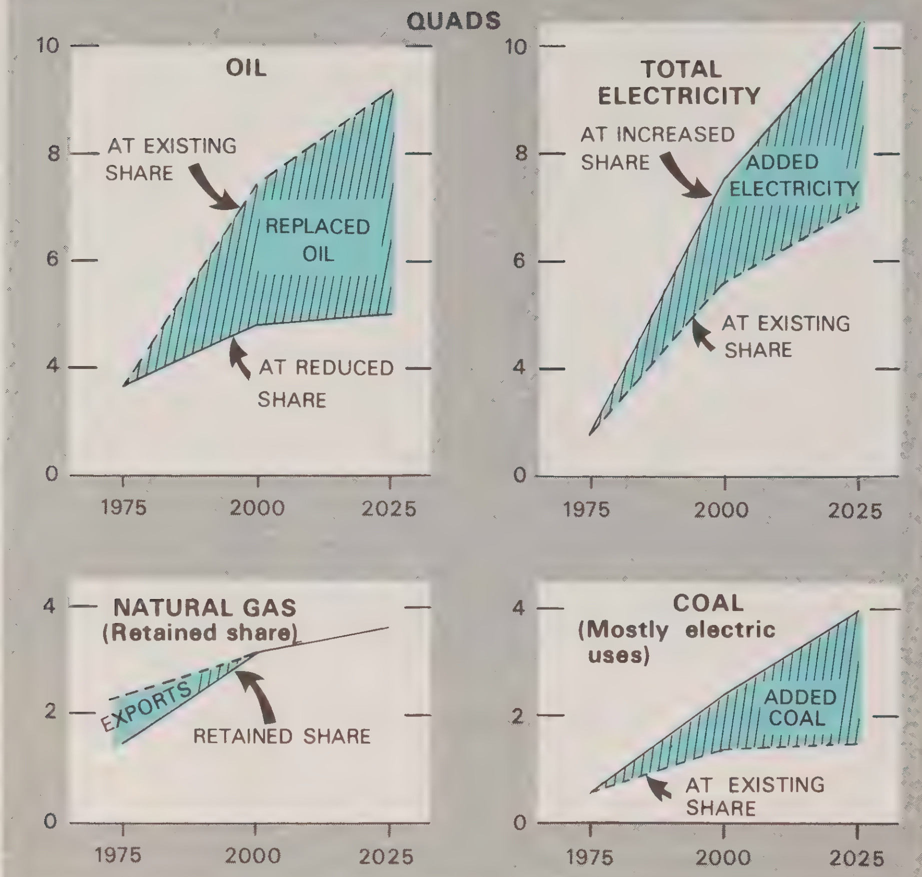
- import ever-increasing amounts of oil.

The increase in oil imports is ruled out, in this assessment, because of the precarious world oil supply position after 1985. Substantial increases in the efficiency with which energy is used already are allowed for in this assessment. Further gains in efficiency and the further elimination of the unnecessary use of oil undoubtedly could be made, but the margin of saving is probably small before severe strains would develop in the use of energy. Efforts to find and produce more oil and natural gas in Canada are a matter of high priority. However, the supply position outlined in Chapter 5 has already included a substantial expansion of oil and natural gas supplies from new sources.

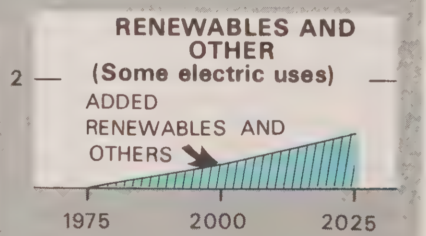
The fourth of the above adjustments -- the substitution of other energy resources for oil -- remains to be exploited. That substitution, along with implementing to the full the potential for further reductions in demand and the benefits of further exploration and development of oil and natural gas, are, therefore, particularly critical considerations.

Reducing demand for oil

In the above illustration, the principal requirement is to "back out" almost one-half of the potential increase in demand for oil. By 2000, the production of oil is shown as higher than current production but at a level which probably can be sustained, at least until 2025, but not high enough to sustain the share of oil in the total use of energy. Increases in demand for energy would be met principally by further increases in electricity, natural gas, coal and the renewable resources -- by a combination of resources most of which are "inexhaustible" in Canada beyond the time span of this assessment. To meet the objective of this assessment, the share of oil is to be reduced from 46 per cent of total primary energy in 1975, to 30 per cent in 2000 and to 25 per cent in 2025. This is illustrated in Figure 6-3, with the offsetting increases in electricity and renewables and byproduct energy.



CHANGING MARKET SHARES * (per cent)	1975	2000	2025
OIL	46	30	25
GAS	19	20	18
TOTAL ELECTRICITY	35	47	52
COAL	7	19	20
RENEWABLES & OTHER	—	5	10



* SHARES DO NOT ADD TO 100 PER CENT BECAUSE MOST OF THE COAL AND ONE-HALF OF THE RENEWABLES ARE DUPLICATED IN TOTAL ELECTRICITY

Figure 6-3. Oil replacement through substitution.

To try to reduce oil consumption proportionately in all of its uses almost certainly would be inappropriate. Other forms of energy are more readily substituted for oil in some uses than in others. Transportation (mobile energy) constitutes the most difficult area of substitution. In some non-energy uses, such as a part of the petrochemical feedstock requirement, it would also be difficult to replace oil. Even after allowance for substantial conservation efforts and increases in efficiency, the energy requirements for transportation and industrial use are expected to increase more rapidly than demand in the residential and commercial sectors taken together. Thus, the greatest increases in demand will be occurring in the sectors which are heavily dependent on oil, and where substitutions to other energy resources are particularly difficult.

A better approach than proportionate reductions within each sector would seem to be to take almost all oil out of residential and commercial space heating and leave proportionately more oil for transportation. To do so, would require solving the problem of the mix of refinery products. Gasoline, diesel fuel, furnace oil and other oil products are complementary refinery products, even though their peak seasonal uses do not coincide. To effect a pronounced change in the refinery mix is a significant, but not impossible, undertaking. The problem is eased somewhat by the reduction, relative to total demand, of the quantity of oil which is being refined. This "squeeze" on total oil supply will provide incentives to change refinery methods to use all of the fractions of oil as effectively as possible in new combinations. However, even if most of the oil could be transferred from space heating to transportation, the transportation requirements would by no means be fully met in 2000, let alone in 2025. If one-half of the requirements of industry also could be transferred to transportation, a deficit would still remain for the transportation sector. Three choices would then be available to meet the energy needs of the transportation sector:

- reduce transport demand further;

- acquire more oil; and

- substitute some other form of energy for oil for part (say, one-quarter or more) of the transportation requirements.

The acquisition of significant amounts of more oil is assumed to be ruled out by the supply positions already described. In any event, it would simply postpone and aggravate an adjustment process which ultimately would be required. Further reduction in transportation demand, beyond those already provided for in Chapter 4, is a real possibility. There are many ways in which

that could be accomplished by patterns of urban settlement, greater efficiency in the movement of freight (road, rail, air and marine), substitution of advanced communication systems for a significant part of personal travel, and making use of more efficient modes of transport for personal travel. There is great scope for imaginative entrepreneurship and new management approaches to the transportation of people and goods, and to make greater use of communications as a means to reduce travel and to make freight haulage more efficient.

Synthetic gasoline

"A new method of cheaper synthesis of high-grade motor fuel in Germany may go far toward the solution of the motor-fuel problem in the future. The Berlin professor, Franz Fischer, who recently devised means of making liquid fuel synthetically from coal products, has now simplified his process."

-Scientific American, December 1926.

Greater substitution of other fuels for oil in transportation would include greater use of methanol and other liquid fuels, and possibly hydrogen in place of some gasoline or diesel fuels. It would also require an increase in electrical transport -- rails, cars, urban transit -- in ways which incorporate technological and design improvements to increase the potential of electricity in transportation, using electricity derived from non-oil resources. "On-site" and other "off-highway" transportation, such as farm and factory vehicles, or those serving mines and forestry, possibly can be made less dependent on oil products. Greater use of very small "commuter" and "shopping" carts, mostly electric, operating on designated laneways or pathways is another oil-saving possibility.

Offsetting to some extent the reductions in the transportation sector are the very sizeable transportation increases in the energy sector itself. A number of additional, long-distance pipelines for oil and natural gas will be needed; possibly LNG tankers for Arctic gas, a considerable increase in coal transport by rail, slurry pipeline, ship or, as SNG, by pipeline and more high voltage transmission of electricity. The need for vast earth-moving projects for strip-mining creates another resource transportation requirement much of which can be effectively met by electricity.

There remains the requirement to ensure that other forms of energy can be used to make up for the oil taken away. Natural gas, electricity, biomass and solar heat could be substituted for oil in space and water heating. In addition, district heating systems might be used, based on low-thermal, byproduct or waste heat from industries, utilities and city garbage. For some range of industrial uses, wood, coal and natural gas can be used. Thus, the energy substitutions will not always be simple one-on-one replacements. Complex chains of substitutions and changes in energy demand patterns are required.

"By necessity and design, synthesis gas from coal will be the chemical raw material of the future."

-R.J. Hughes, Senior Vice-President, Union Carbide Corporation, New York, Oil and Gas Journal, August 1977, p. 456.

Energy storage, transportation and transmission

Storage

In times of uncertainty, provision for larger storage of energy resources takes on added importance. The first form of storage is to leave resources where they are, usually in the ground. Uncertainties as to the actual amounts which are contained in the natural deposits, and delays in getting them to markets when needed, are shortcomings of natural storage. Hence, the acquisition of information on available resources through extensive geological evaluation and exploratory programs has a high priority.

A form of energy storage which has not yet achieved much significance in Canada is expected to acquire considerable importance over the coming 25 or 30 years. That is heat storage associated with individual space heating requirements in homes, commercial and industrial buildings, and for district heating or multiple-unit heating requirements. Typically, the heat storage facilities will be used in conjunction with more advanced heat transfer systems to increase overall efficiency. These storage facilities, in many instances, will rely on heat sources not now explicitly built into energy systems, for example, passive or active solar systems, off-peak electricity generating capacity, byproduct and waste heat from dwelling units and from commercial buildings, industries, public utilities and, possibly, subway systems. Taken in total, heat storage is expected to make a significant contribution to energy balances and to the efficiency

with which energy is used. Heat storage is particularly useful for smoothing out daily, weekly and seasonal load requirements.

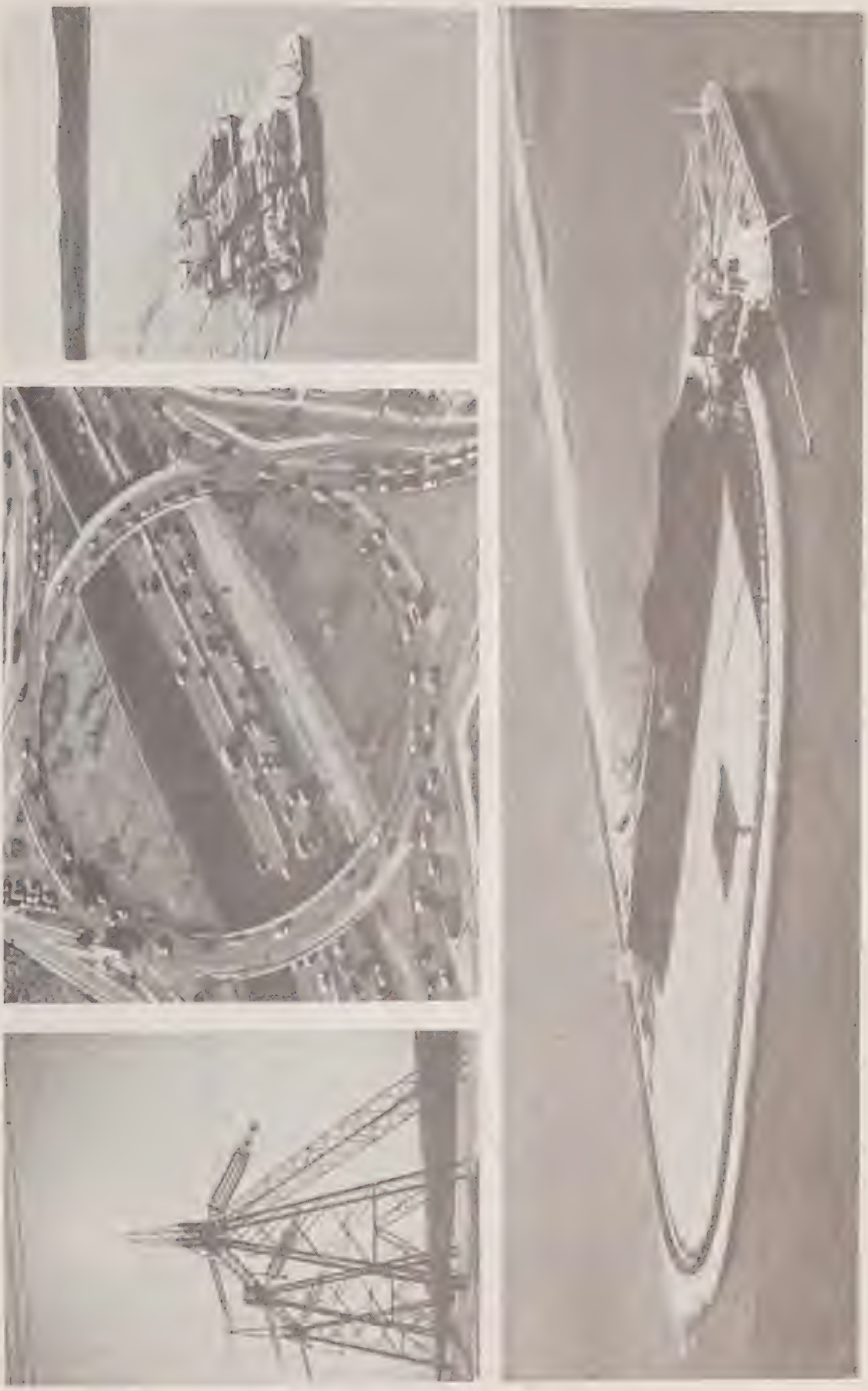
International agreements are being entered into for emergency allocations. As a country with vast potential resources, Canada undoubtedly will be looked upon with increasing interest as a possible source of emergency supplies, or for the production of goods and services which are heavily energy-dependent.

For **coal, oil and uranium**, an increase in conventional stockpiling is a practical, but costly, form of storage. For example, instead of keeping on hand 90 days' supply of oil, 120 or 180 days might be kept. The spent fuel from electric generation by the present CANDU method can be stored indefinitely for reprocessing when more advanced technologies justify.

For **natural gas**, three forms of storage might be considered: leave proven reserves in the ground, possibly financing their storage by equity (or loan) provision by major distributors, customers, or by governments; produce and transport the natural gas to other large, natural storage reservoirs such as salt domes, especially when these are located fairly near to market centres; liquefy and store the natural gas as LNG. All three methods of storing natural gas are expensive, but one or more might be necessary to provide assurance of uninterrupted supplies for market expansion.

Electricity and many forms of renewables, (e.g. solar, wind, and, to some extent, biomass) are difficult to store. Short-term heat storage is a possibility. Batteries at present are the principal form of storage for electricity (apart from hydro reservoirs). However, much better performance characteristics and better management and handling of battery systems are needed if batteries are to add appreciably to storage and, hence, to the application of electricity. Another form of electricity "storage" is the provision of spare generating capacity which can meet unforeseen increases in demand. Two other forms of storage of electricity in larger amounts are receiving increasing attention. Off-peak electrical capacity can be used to pump water up to storage basins for the subsequent generation of hydro power. Hydro storage is also possible by use of windmills to pump water. Unused electrical generating capacity can also be used to produce hydrogen (and oxygen) by electrolysis. The hydrogen can be stored, in pipelines and tanks, and in the form of hydrides or other hydrogen compounds. The oxygen from the electrolysis could also be a valuable energy adjunct, for example, for use in underground fire-flood or other in situ oil or coal operations.

While the significance of these storage capabilities are of interest in smoothing out short-term imbalances, for the purpose of a long-term assessment, the principal emphasis is on proving up resources in large quantities to provide assured energy supplies to meet future needs and to facilitate interfuel substi-



Transportation and energy form a particularly critical relationship.

tutions. The emphasis, therefore, is on three forms of long-term storage:

- Evaluating resources well in advance of anticipated needs.

- Producing and storing, perhaps in natural reservoirs, stable resources such as oil, coal, uranium and natural gas. For example, the abandoned Wabana iron ore mine on Bell Island, Newfoundland, could possibly hold 100 million barrels of oil. Caverns left after dissolved salt has been leached could be used in the Magdalen Islands, southern Ontario and Alberta.

- Providing spare production, refining and transportation capacity beyond that required in the short run. This provision has particular relevance to electrical generating capacity.

Storage-in-place has long been a characteristic of long-term contracts for natural gas and for uranium sales. An assured supply for 20 to 30 years is a common expectation for marketing those commodities. Similarly, a utility typically provides electrical generating capacity perhaps 25 per cent greater than the anticipated peak load over, say, a 10-year forward period. In many instances, that has proven to be a wise precaution.

As with most other parts of the energy system, the anticipated increase in storage entails higher costs, greater amounts of financing and considerable technological advance. Long-term storage capabilities, of one kind or another, can help bring about interfuel substitutions by providing assured, long-term future supplies. During times of resource substitution, energy storage helps to provide resiliency and flexibility.

Energy transportation and transmission

The long-term energy assessment calls for a substantial expansion of energy transportation and transmission facilities. Probably at no previous time have both the magnitudes and the innovative requirements of increased energy transportation been greater or more diverse. Oil and natural gas pipeline extensions are expected to exceed the mileage of existing pipelines in Canada by an appreciable amount. Much of the pipeline construction will be over especially difficult, untried terrain. Some of the construction probably will be through deep northern waters, from one Arctic island to another, and through iceberg-infested channels.

Arctic oil and gas transport will require specially designed barges, icebreakers and, for natural gas, probably LNG tankers and processing facilities as well as pipelines. Coal transportation will be greatly extended within the coal producing provinces, interprovincially (probably including from western Canada to Ontario), and to export markets. New rail, unit-train and port facilities will be required, and probably slurry pipe-

lines at least for intermediate distances of 200 to 400 miles. SNG production from coal might be transported by modified gas pipelines. Biomass energy resources, peat and urban wastes require considerable materials handling and transport. A great deal of technological development undoubtedly is called for if the efficiency of these operations is to be significantly improved.

Long-distance electrical transmission by high-voltage lines will be greatly increased, particularly in Quebec, Manitoba and British Columbia, but quite probably also in Labrador (where submarine cables might be one component of a transmission system), northern Alberta, and in the Yukon and Northwest Territories. Another feature of electric power transmission is expected to be the systematic expansion of regional power grids in several parts of Canada. These will have both east-west and north-south connections, being integrated to some extent with grids in the United States. The electrical transmission grids might ultimately become nation-wide, or be interconnected on a continental basis.

Great technological improvements in transportation can be expected over the coming 25 to 50 years. These will apply to the transport of solids, and solid-liquid slurries, electrical transmission, cyrogenic (low temperature) transport of gases, and long-distance pipeline transport from frontier areas. Conventional transport systems (air, road, rail, marine) also can be expected to undergo great change. For many of the transportation and transmission innovations, close international cooperation will be most helpful. For some (e.g. Arctic transport, mountain transport, high voltage electricity transmission, and cold climate transport), Canada can be expected to establish a world leadership position, and develop technologies and skills which are exportable.

The financial requirements and the technological innovations needed for the increased energy transportation systems will be substantial. The inclusion of massive, new and innovative transportation and transmission systems is an essential part of any assessment of long-term energy balances.

Behind the increases in efficiency and the adoption of new techniques, lies the question of integrated transportation systems. Details of energy storage, transportation and transmission innovations are one of the strategic issue areas for systematic and comprehensive investigation.

Energy balance and recommended programs

Chapter 13 draws together the 28 principal recommended programs of this report. These serve 5 main policy elements --

transforming end-uses, providing for a consolidated energy supply, facilitating the processes of adjustment, realizing the economic and social opportunities, and ensuring public participation. All of those programs, policy elements and the supporting indicative and performance targets are directed at the objective of achieving and sustaining, in a fast-moving, flexible way, satisfactory energy balances. "Satisfactory", in this context, means capable of providing for acceptable levels of economic performance and personal and community well-being. Although the energy balances are undergoing continual change, they at all times will provide sustainable energy self-reliance for Canada. The objective requires that appropriate, but different, balances be struck in all provinces, regions and localities. That requirement, in turn, calls for the greatest, practical use of energy resources indigenous to each location.

Some of the required, substantial changes in energy supply and in patterns of energy use have been illustrated in this chapter, and a number of difficulties have been noted. The process of adjustment, which are outlined in Part III following, contain another host of difficulties standing in the way of achieving satisfactory energy balances. Price differentials, for example, and achieving satisfactory prices for the various energy forms within changing patterns of energy use are among those difficulties. Ensuring that financing availability meets the apparent priorities for the changing energy balances is another requirement. The uneven impact of environmental concerns and of technological advances are others. The long list of factors must all come together in some satisfactory combination if the new energy balances are to be achieved, and achieved without undue disruption and hardship.

It is essential to recognize that these are <u>energy-balance programs</u>, not just conservation programs. They involve the progressive introduction of structural changes in demand, supply, support systems and institutions, geared to the particular needs and opportunities of each community and province, coordinated within regional and national programs.

Full-scale action cannot be undertaken on all programs at once. However, elements of most programs will inevitably proceed at the same time and these can be systematically coordinated through task forces, committees and the Energy Information and Participation Program. For example, work will proceed further on consumer products, transportation, coal policy, housing retrofit and re-design, technological innovations, resource evaluation, manpower requirements and employment opportunities, financing and ownership, and energy pricing. Areas which also require concerted attention for all projects are questions of social acceptability and the necessity of institutional and regulatory changes to support the energy transformations. Very deliberate attention should be paid to those matters as part of every energy

undertaking. To concentrate on the achievement of satisfactory balances during times of profound change is to focus on the need for a dynamic, comprehensive approach to Canada's energy future. It is within this balancing process that the objectives, the targets, the policy elements, the factors of adjustment and the recommended actions all come together as a National Energy Program.

The above programs call for the establishment of greatly altered patterns of energy use to match the new supply capabilities. In space heating, for example, the objective is to eliminate oil to the greatest practical extent by increasing the use of natural gas, electricity (with heat storage, co-generation, district heating, etc.), solar, biomass and byproduct energy in combinations particularly appropriate to the different provinces, communities and regions. This requires substantial re-organization of distribution, marketing, pricing, institutions and personal habits as well as new supply capabilities.

7. PROVINCIAL ENERGY BALANCES IN A NATIONAL CONTEXT

Chapter guide

- *Provincial jurisdiction over energy supply and demand is extensive; sizeable difficulties will be encountered in coordinating jurisdictions and priorities so that each province and region realizes the gains to be had from the national "concertation" process.*

- *The principal provincial and regional objective is to reduce substantially the vulnerability of the Atlantic provinces and Quebec to disruptions in supply of imported oil, and to prevent a growing dependency of Ontario on imported oil.*

- *As far as practical, the objective is that the energy deficit regions of central and eastern Canada would achieve a much greater reliance on indigenous energy supplies, and obtain any additional requirements from the energy-surplus provinces and frontier regions.*

- *Appropriate benefits will have to accrue to the energy-surplus provinces (Saskatchewan, Alberta and British Columbia) and the frontier regions; these benefits often will take the form of higher incomes, industrial and other economic development.*

- *The economic and social future of Canadians, not only in the energy-deficit provinces and regions, but in all parts of the country, will depend very much on how successful the national links are forged. New energy balances suitable to each province or region will best support economic and social environment for that region if coordinated into national programs.*

Chapter 7. PROVINCIAL ENERGY BALANCES IN A NATIONAL CONTEXT

The provinces and energy self-reliance

This chapter cannot explore in detail satisfactory energy balances over the long term, province by province. Further comprehensive investigation of those possibilities are part of a recommended <u>strategic issue area</u>.

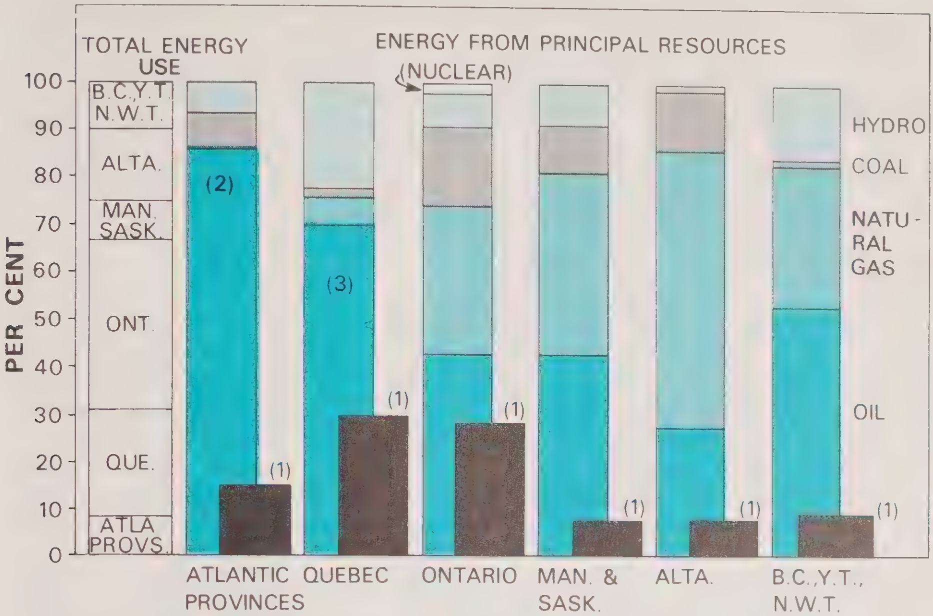
Satisfactory energy balances on a national basis rely very heavily upon the policies and actions of the provincial governments. The provinces control resource development within their boundaries; they have a major impact on tax, royalty, land-sale and leasing arrangements, and they regulate many aspects of the sale and the principal uses of energy (transportation, housing, urban and industrial development). The provinces also are heavily involved in environmental and health considerations, research and development, public information, financial and manpower policies. Action by the provinces to meet economic and social priorities also have major impacts on Canada's energy system. However, the energy balance which each province strikes for its own purposes, when combined with the action of other provinces, will not necessarily result in a satisfactory energy base for Canada as a whole. Disagreements about priorities and inconsistencies among provincial programs, or their timing, could result in an energy system which is badly distorted or inadequate, thereby frustrating many of the provincial priorities.

In any assessment of energy balances for each province (as for Canada as a whole), the economic and social aspirations of the people of the province are a matter of dominant concern. A provincial government, in its attempts to accommodate those aspirations, will adopt a wide range of industrial, fiscal, resource, manpower, environmental and community policies, all of which impact upon energy requirements and all of which, in turn, depend heavily upon the available energy. Provincial development policies will tend to increase energy demands and, at present, will tend to cast those increases in terms of conventional forms of energy -- oil, natural gas and electricity. <u>A fundamental conclusion of this assessment is that the economic and social objectives of all provinces can be more fully accommodated if they are explicitly coordinated across Canada within a national energy program. Few relationships at this time offer a more obvious opportunity to further the interests of each province than by taking a national approach to energy and to the related industrial, economic and social progress.</u>

Figure 7-1 (which was also shown as Figure 4-6) illustrates the proportion of each region's energy which is supplied by each of the principal energy resources. The heavy dependency of Quebec and the Atlantic provinces on imported oil is evident. Quebec relies on oil for more than 70 per cent of its final net energy, and the Atlantic provinces, for about 85 per cent. Together, Quebec and the Atlantic provinces use more than 40 per cent of all oil used in Canada, in contrast to about one-third of total energy. Until 1977, virtually all of those oil requirements were met by imports. In 1977, the new Sarnia-Montreal pipeline supplied about one-half of Quebec's needs with oil from western Canada. Expansion and extension of the pipeline would be essential to reducing dependency on imported oil (unless substantial quantities of oil are discovered off the east coast). The proposed natural gas pipeline through Quebec and to the Atlantic provinces also would contribute significantly to satisfactory, long-term energy balances in those regions. Beyond those additional sources of energy, a considerable increase in the use of energy resources indigenous to those regions is called for.

Economic and demographic developments across Canada undoubtedly will appreciably change the distribution of energy use over the coming 25 to 50 years. No explicit allowance is made here for changing shares. On the basis of current patterns of use, the requirements for primary energy and for oil in each province or region would double by 2000, and increase by a further 25 per cent by 2025. If Canadian production of oil in 2000 were to achieve the 2.5 million barrels per day set out in the energy balances of Chapter 6, it would no longer fully meet the requirements even of western Canada and Ontario unless significant substitutions away from oil are made. If oil constituted only 30 per cent of total primary energy needs by 2000 (as called for in this assessment), instead of 46 per cent as at present, Canadian oil production could serve the oil requirements of all regions.

The most pressing substitutions are in the Atlantic provinces and Quebec, but a reduction in demand anywhere in Canada which freed up additional supplies for the oil-importing regions would have a beneficial effect. On the basis of present shares, Quebec and the Atlantic provinces would require about 1.5 million barrels of oil per day by 2000, and over 1.8 million by 2025. Even with some expansion of the Sarnia-Montreal pipeline, oil imports to serve Quebec and the Atlantic region could exceed one million barrels per day before the year 2000. If the share of oil in total energy consumption is reduced as provided for in this assessment, requisite imports of oil might exceed 500 000 barrels per day by 2000. They could be substantially larger if deliveries by the Sarnia-Montreal pipeline cannot be readily increased, either because of lower production in western Canada or because of demands in Ontario and western Canada.



(1) Percentage of Canada's total oil demand
(2) Imported oil
(3) In 1977, about one-half supplied by western Canadian oil via Sania-Montreal pipeline; balance imported

Figure 7-1. Regional distribution of energy.

To avoid so great an increased reliance on imported oil in Quebec and in the Atlantic provinces by the year 2000, and to prevent dependency on imported oil in Ontario, this assessment would require that indigenous energy resources in those regions supply about one-third of total requirements (compared with about 10 per cent at present), and that the energy-surplus regions of Canada supply most of the remainder (compared with about just over 50 per cent at present).

A basic target is to provide, by 2000 or soon after, at least one-third of the energy requirements of central and eastern Canada from their own indigenous resources, and virtually all of the remainder from the energy-surplus provinces and frontier regions.

The advantages to the energy-deficit regions of Canada of a national approach and of a National Energy Program seem obvious. The full assessment, including economic and social aspirations, indicates that significant advantages can accrue to the energy-surplus regions as well.

In summary, the Atlantic provinces and Quebec are most vulnerable to the precarious future world oil situation. They require

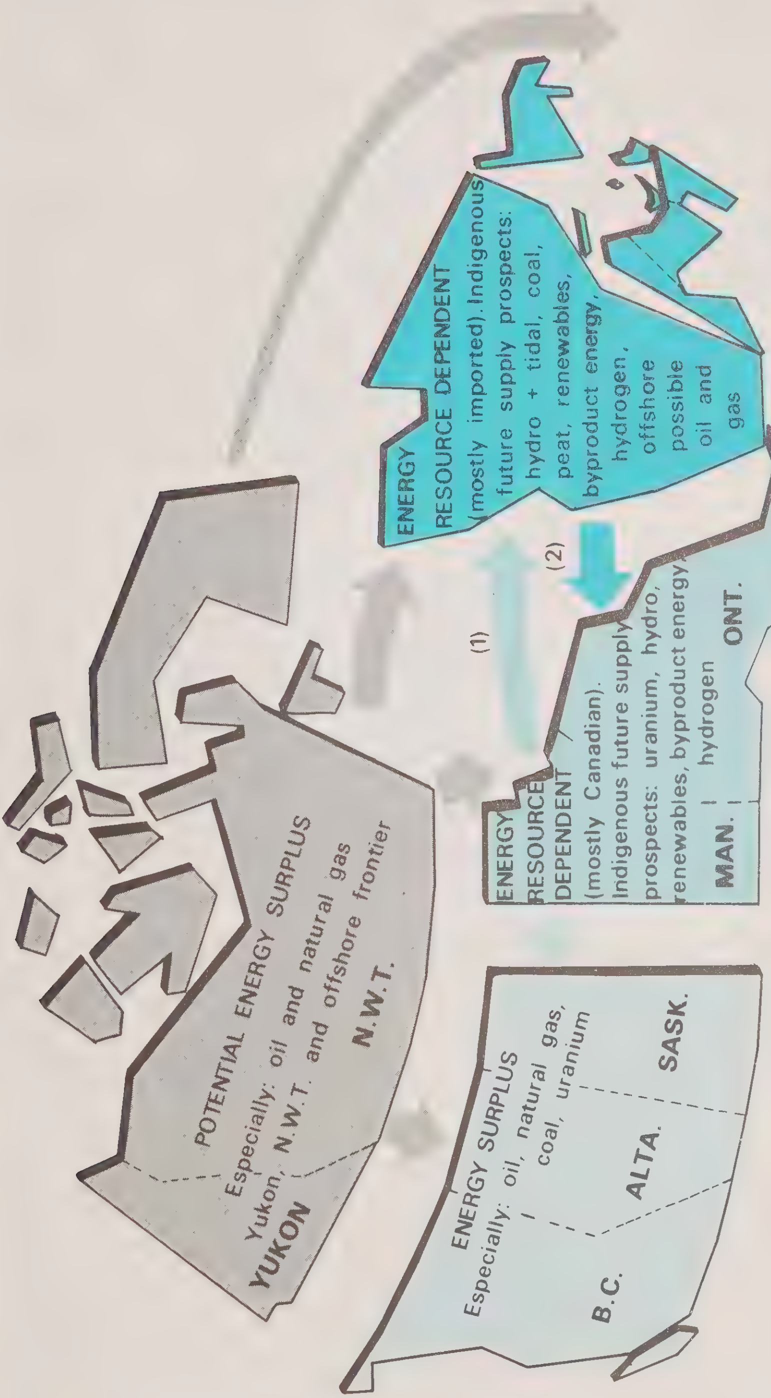
the greatest energy transformation. Ontario is potentially vulnerable and is substantially dependent upon outside energy resources. Hence, central and eastern Canada have most to gain directly from national energy programs, whereas the western provinces will experience their gain from the national and international marketing of energy resources and of energy-intensive products, and from other economic and social opportunities which will result from their strong resource base.

Summary for provinces and regions

Figure 7-2 depicts the energy-surplus and energy-deficit regions of Canada, based upon present and fairly assured, future energy supplies. A "deficit" region is one which relies heavily on outside sources of energy. A region's energy potential can be further developed and its energy demands be altered to match, in large part, that regional potential. For example, the Atlantic provinces have the Gull Island hydro potential of Labrador (and, hence, also a hydrogen potential), a greater coal potential, peat, tidal power and other renewable and byproduct energy resources, but the region is designated as "energy deficient" because of its present, heavy reliance on imported oil. Figure 7-2 also notes the potential resources in each region which might be developed as a means to achieving greater self-reliance. Beyond that, the energy deficient regions would look to the western provinces and frontier areas to achieve self-reliance within a national context.

The Atlantic provinces and Quebec are heavily dependent on imported oil. As noted in Figure 7-2, the Atlantic provinces have indigenous energy resources which can, under appropriate circumstances, help to increase their degree of energy self-reliance. However, oil and natural gas shipments from other regions of Canada would be an essential supplement. Nuclear power already is being introduced to both regions although, in both, remaining hydro power potential can be expected to moderate the expansion of nuclear power until near the end of this century. Canadian supplied oil, natural gas and uranium, if arrangements are made on a national scale for their delivery, could adequately complement the indigenous resources of Quebec and the Atlantic provinces to achieve energy self-reliance for those regions within a national context. Thus, the deficit regions probably cannot achieve full provincial or regional self-reliance, but they can become Canadian energy self-reliant.

The Sarnia-Montreal oil pipeline, the recently established Maritime Energy Corporation, the possible construction of an LNG port on the Atlantic coast, the proposed Quebec-Maritime natural gas pipeline and the possibility of a natural gas pipeline from the eastern Arctic are among the current initiatives to overcome the vulnerability of eastern and central Canada to oil imports. Together, they could form an outstanding example of coordinated, national energy programs. A number of other initiatives can be



(1) Western energy resources move east (e.g. Sarnia-Montreal and Quebec-Maritimes pipelines).

(2) Avoid imported oil moving into Ontario; by western and northern oil and gas indigenous energy and possibly moving East Coast + East Arctic oil and gas into Ontario.

Figure 7-2. Illustration of regional energy supply position.

taken, including much more extensive development of the indigenous resources of the regions, and greater efforts to alter demand patterns to the future available supply.

Ontario is more than 40 per cent dependent on oil and consumes 30 per cent of all of the oil used in Canada. At least part of Ontario's oil requirements would have to be met by imports if Canadian oil resources are not adequately developed. At present, Ontario's indigenous energy resources (mostly hydro power and uranium) supply about 10 per cent of the province's energy needs. In addition to oil and natural gas from western Canada, Ontario relies upon thermal coal imported from the United States. In total, the province has the most evenly balanced use of energy resources, but it is seriously energy deficient. Nuclear power from indigenous uranium and local, byproduct energy sources can reduce Ontario's dependency somewhat, but the availability of oil, natural gas and possibly coal from the energy surplus regions of Canada will be of crucial importance to Ontario probably through to 2025.

Manitoba relies upon sizeable hydro power resources for much of its energy, and is well located to take advantage of oil, natural gas, coal and uranium from the other western provinces. For a time, Manitoba might be a net exporter of electricity to the United States. It might also participate to an increasing extent in regional electricity grids with Saskatchewan and northwestern Ontario. Manitoba might be able to use a favourable energy position to participate in the growing manufacturing and servicing requirements for resource-led projects in western Canada.

An expanded electrical grid system or substantial, additional energy requirements for resource industries might warrant nuclear installations in Manitoba before the year 2000.

Saskatchewan derives an advantageous energy position from lignite coal, heavy oils, uranium and some natural gas. Its large reserves of uranium and heavy oils will enable Saskatchewan to achieve a net export position in energy resources probably throughout the entire 50-year period here under review. Thus, the economic development and social future of the province rests on a very favourable energy base.

Alberta's use of energy calls on a diversity of its own abundant resources -- mainly natural gas, but supported strongly by oil and coal. The principal advantages to Alberta in the long-term energy future come from the gains in income and wealth. These will result from the diversity of industrial production, the sale of energy resources and energy-intensive products within Canada, and the possible export of energy resources surplus to long-term Canadian requirements, and the export of energy-intensive goods and services. An interesting (but fairly easy) resource shift has taken place in the past 15 years in Alberta's

pattern of energy use. Oil has declined quite steadily (from 40 per cent of the total in 1961 to about 28 per cent in 1975) and both natural gas and coal have increased in relative importance -- coal coming up from 5 per cent to 13 per cent, and natural gas, from 53 per cent to 58 per cent. Thus, coal has made the larger relative increase, based mainly on its use for thermal - electric generation.

The change in the pattern of Alberta's use of resources over the past 15 years is a fair reflection of what this "Energy Futures" assessment indicates as a possibility for Canada as a whole over the coming 25 to 50 years. The share of Alberta energy supplied by oil is on the target here set down for Canada by 2000, but the abundant use of natural gas in Alberta is nearly three times what is thought to be sustainable for Canada as a whole. The rapid increase in the use of electricity results mainly from the demands of resource and industrial development, and is fueled principally by coal. If nuclear power is to come to Alberta within the next 25 or 30 years, it would most likely be in organic-cooled reactors for steam and hydrogen production for use in the oil sands and heavy oils.

British Columbia, like Alberta, is rich in energy resources, although its oil and natural gas reserves and production are much smaller than Alberta's. This is partly offset by substantial hydro resources which, for electricity generation, approximately match Alberta's use of coal. In British Columbia, coal also holds great potential for thermal use. The eventual installation of nuclear power in British Columbia is regarded as a possibility perhaps in the late 1990s. British Columbia also has considerable income-generating potential from sales to the rest of Canada and abroad of energy resources (mostly coal) and increased sales of other resource and industrial products which benefit from the favourable energy base.

Yukon and Northwest Territories and offshore frontier areas do not account for a large part of Canada's total energy production or use. Apart from some local oil and gas production and hydro-electric generation, their energy needs are met by supplies brought in from other parts of Canada. Additional hydro potential exists, but the obvious future interest, from the point of view of Canada's overall energy balance, lies in the oil and natural gas potential. A substantial part of Canada's total energy investment seems likely to take place in those areas under some of the most difficult physical conditions to be encountered anywhere in the world. The physical and technological difficulties, combined with the requirements for appropriate environmental, land, cultural, and political policies set the Yukon and Northwest Territories, the offshore islands and central regions apart as one of the greatest challenges to bold, imaginative leadership by government, industry and the local people.

The provinces and the national context

A prime objective for a national energy strategy is to make Quebec and the Atlantic provinces essentially independent of imported oil and imported LNG by the year 2000 -- to permit those regions to become Canadian energy-reliant. This would be done by rigorous conservation efforts, the development of energy resources indigenous to those regions, and by supplying oil, natural gas and uranium from the other provinces as required. The increasing energy needs of Ontario and Manitoba would also be met mainly from Canadian resources. The strategy also requires that adequate incentives be provided to energy-surplus provinces (Alberta, British Columbia and Saskatchewan) and in the potentially energy-surplus northern and offshore regions to ensure that energy resources are forthcoming from them to central and eastern Canada. Many of the incentives can take the form of support for the industrial and international trading policies of the energy surplus provinces and regions, and support for their other economic and social aspirations.

There is nothing easy about the accomplishment of that network of strategic objectives, particularly when they confront so many different provincial and federal priorities and programs. Serious conflicts of interest and many practical difficulties are inevitable among the various elements of the above strategies and among the provincial priorities for energy and for economic and social development. Significant regional shifts can be expected in industrial structure, in other economic activity, in incomes and in social well-being. These will, at times, increase national tensions.

To get agreement among the provinces on energy priorities for Canada will be as difficult in the future as in the past, even if they fully accept the gravity of the long-term situation. Even with agreement, the requisite energy substitutions and the accompanying structural changes are extremely complex, but the advantages of dealing with them on a national basis are readily apparent.

Nuclear energy, like natural gas and oil, demonstrates the advantages of a regional and national approach. The technologies are vested in a federal agency, as is essential control over the uranium fuel, particularly as this moves from one province to another, or is exported and imported. Increments to nuclear generating capacity are typically in large blocks. The supply additions are, therefore, "lumpy", and efficient operation of the plant and of the electrical grid might require interprovincial or international movements of electricity. Large-scale projects such as the Gull Island hydroelectric development in Labrador are related considerations which can involve a number of provinces and the federal government. In the Atlantic provinces, the Maritime Energy Corporation has been recently established to help to ensure

efficient, unified energy developments. The complementary energy supply programs are drawn together in a Consolidated Energy Program in which the various provincial, regional, national and international interactions can be assessed comprehensively and developed systematically and progressively through time. The related materials and equipment inputs, manpower and financial requirements will all undergo great changes across Canada and would benefit greatly from overall policies of coordination and integration. As one illustration, Winnipeg, for example, might enlarge its historic role as a service centre to western provinces, picking up some of the industrial and service needs of a rapidly growing western economy.

Thus, the complex energy inter-relationships are closely tied to provincial and regional resource, construction, industrial and community policies. These, in turn, are inexorably linked with international trade, employment, prices and incomes, taxation and other fiscal policies, monetary policy, investment and financing, urban settlement, and the environment -- in short, to the economic and social well-being of all parts of Canada. It is in the interface of energy policies and the broader economic and social policies that many of the influences of the federal government, of industry on a national scale, and of people in all parts of Canada come into play, and in which many of the advantages of national approaches can be demonstrated.

Undoubtedly, the long-term energy situation, so far as it can be perceived at this time, supports a relative shift in economic activity toward the energy-surplus regions. However, the opportunities in the energy-surplus regions do not require a decline in activity in other regions -- quite the contrary. The great merit of a well coordinated national approach is that the provincial, regional and national opportunities can be mutually supporting. It is within the context of imaginative, well integrated national development strategies for energy, and for industrial, economic and social development that resolution of the inherent conflicts and difficulties must be sought. As noted in Chapter 1, the national approach is a matter of public perception, not just a coordination of provincial and federal programs.

Government and the public

Involving the public in energy planning has been the objective of a number of recent federal and provincial initiatives. The Berger Inquiry into the social and environmental impacts of proposals for a pipeline through the Mackenzie Valley, and the National Energy Board's northern natural gas pipeline hearings, are two examples at the federal level. Recent provincial initiatives include the Royal Commission on Electric Power Planning in Ontario (the Porter Commission), the inquiry on the implications of expanding uranium mining in Saskatchewan, the periodic hearings of

the Alberta Energy Resources Conservation Board appraising that province's energy futures, and similar hearings by the British Columbia Energy Commission. The Nova Scotia Energy Council carries on assessments in that province, and the public hearings of provincial public utilities generally provide considerable energy information. All of these forums represent attempts by governments to consult the public on specific policy issues which affect energy futures. To maximize the national advantage from such diverse forums, a process of "concertation" is called for. To assist in that process, a National Energy Information and Participation Program is recommended. The program would involve task forces and public forums in all parts of Canada, making available national reference systems of energy accounts, energy targets and performance indicators for continual discussion and revision. Chapter 12 and the recommended programs of Chapter 13 deals with Energy Information and Participation Program in a broader context.

Part III

THE ADJUSTMENT PROCESS – OVERCOMING THE CONSTRAINTS

6. PERSPECTIVE ON THE ADJUSTMENT PROCESS

Chapter guide

- *Many strategic factors come together to determine whether adjustments can be made to achieve satisfactory energy balances. The principal strategic factors are:*

  a) energy prices and pricing;

  b) financing, ownership and control;

  c) technology, research and development;

  d) environmental, health, land-use and other social considerations;

  e) institutions, regulations, administration and management provisions;

  f) manpower, equipment, materials and infrastructure; and

  g) information, communication and participation programs, including energy accounts, targets and programming.

- *Taken together, the strategic factors provide a framework for adjustment within a National Energy Program.*

- *The adjustment process will be more difficult than that of the past 25 years because:*

  a) changes in energy demand and supply will be toward less preferred rather than more preferred patterns;

  b) for many adjustments, the process of transition is at a very early stage (e.g. renewable resources, increasing energy efficiency, structural changes in demand); and

  c) risk and uncertainty will be much higher during an era of rapid transition.

- *The objective, in dealing with the adjustment factors individually and collectively, is to ensure that they are fully supportive of the long-term energy objectives and targets; in the last analysis, the impact of the adjustment process will determine the success or failure of Canada's future energy program.*

- *Much greater public awareness, public learning and public participation will be an essential part of the future adjustment process.*

- *Indicative, national achievement targets with 1985, 1990, 2000 and 2025 as reference years will focus attention on the magnitude of the tasks ahead, and be the basis for assessing performance and for revising priorities.*

Chapter 8. PERSPECTIVE ON THE ADJUSTMENT PROCESS

The preceding chapters have outlined why, in terms of deteriorating world energy prospects, Canada should seek to achieve sustainable self-reliance in energy. They have indicated that in the long run substantial alterations in patterns of demand and supply can perhaps enable sustainable energy self-reliance to be achieved in ways which provide satisfactory economic performance, increase in incomes and enhanced personal and community well-being. The preceding chapters, however, only touched upon the extreme difficulties to be overcome if, by the year 2000, Canada is to achieve satisfactory and sustainable self-reliance in energy. No less important to a satisfactory energy balance than the physical resources to sustain it are the complex processes that must be put in place if the transformation is to take place.

The objective of policies to deal with the factors of adjustment is to ensure that, individually and collectively, they fully support the long-term objective of sustainable self-reliance in energy, and support the targets and programs which will achieve the transformation. In the last analysis, it is not the objectives or the targets which determine the success or failure of the energy program, but how well the adjustment is carried out.

Many constraints and roadblocks stand in the way of the achievement of satisfactory energy balances even when the physical resources and the technologies are clearly available, and even if the economic viability can be demonstrated. At times, these constraints arise because we either cannot see sufficiently far in advance what has to be done, or we can't bring all the pieces and the people together to do it. Constraints, however, are also challenges and opportunities. It is a function of human genius and human skills to ensure that the transitions are made with a minimum of disruption and hardship. The complexities of the adjustment process will fully tax our ingenuity and effort over the coming 25 years and beyond. The principal processes of adjustment are expected to be substantially put in place between now and the year 2000. Between 2000 and 2025, the transitions will continue to be great, but are expected to proceed along lines which have become fairly well established by the turn of the century.

Twenty-five years is both a long time and a short time in terms of large-scale processes of adjustment. Looking back, oil has achieved its present dominance of world energy supply in not much more than 25 years (though the beginnings go back much further). Oil, natural gas and hydro power have come to provide most of Canada's energy needs in not much more than 25 years. In

1950, for example, coal supplied more than 40 per cent of Canada's primary energy and oil and natural gas together, only about 30 per cent. Oil and natural gas now account for about two-thirds of Canada's primary energy (and a higher proportion of final use). Coal supplies only about 10 per cent. These changes have taken place smoothly and without serious economic and social disruption over that period of time. They illustrate how great the energy supply and demand changes can be in only 25 years.

Steps in the process of adjustment

Two fundamental differences underlie the adjustments of the next 25 years compared with the past:

- the supply and demand changes will be toward less preferred rather than more preferred patterns; and

- for some of the future adjustments, we are much further back in the process of transition than we were in 1950 in respect of the changes then underway.

The first difference noted above refers to the clear advantages which were seen by 1950 and the subsequent years favouring a switch to the abundant, convenient and relatively low-cost energy resources of oil and natural gas, supplemented by electricity. Over the coming 25 years, positive incentives to change will not be so dominant. Necessity will force us to accept higher cost, often less convenient and less preferred, patterns of energy use and supply. Hence, the adjustment process instead of being vigorously pursued as in the past will, in many instances, be resisted and delayed, and brought about by what is deemed to be some form of compulsion, not choice.

Also, imbalances are not particularly serious as long as there is a fall-back resource, abundant in supply, relatively inexpensive and flexible in its uses, which adds resiliency to the system. Over the past 25 years, oil filled that function. Even that more than adequate fuel was back-stopped in Canada by two others -- electricity and natural gas. Coal could also have served as an ultimate fall-back energy resource but, under the conditions of the time, it could not hold its own against such strong competitors.

Now the position has greatly changed. Resources are becoming more expensive, and many show signs of becoming far less readily available. Both flexibility and resiliency are threatened. Large-scale, high capital cost projects, with long lead times, add to the risks and uncertainties. Energy might not be accessible where we are searching, or technologies may not be developed to produce and deliver it at an appropriate time and under favourable economic conditions. The commercial viability of every resource

is undergoing continual change, under conditions of great uncertainty. Increasing participation by governments, in ways which are not always clear in advance or consistent in purpose, add to the uncertainties. Finally, there is a barrage of ways in which public attitudes or those of special interest groups can delay, modify or prevent a project. Throughout all of this complexity of change, the institutions, incentives, regulations and management systems which have grown up over the years will be, in many ways, inadequate or inappropriate.

A general slowing down of population growth, of economic activity and of energy requirements eases the problems of adjustment in some ways, but creates other difficulties. Some of the invested capital is rendered obsolete and pay-back periods on other projects are made longer. Typically, the positive incentives for major adjustments are strongest under conditions of dynamic, profitable expansion over a broad economic base. The expansion in the future is expected to be moderate. Its breadth and magnitude might very well be largely determined by the spur supplied by the energy adjustments themselves. Thus, the energy sector can become a positive factor supporting the pace and direction of economic and social change, but will do so under difficult, attendant conditions.

The second difference noted above refers to the fact that by 1950 the organization, management, ownership, financial systems and infrastructural support systems were well in place to launch a massive change toward oil, natural gas and hydro power. Patterns of energy demand and supply were well established to take advantage of a rapid expansion in those preferred energy sources. Some of the major transitions which are required over the next 25 or 30 years are hardly at the starting gate. Many new frontiers of knowledge must be crossed and many new assemblies of essential inputs organized. A beginning to a substantial deployment of renewable resources, for example, might be compared with the introduction of oil in the early 1900s, or of nuclear power in the late 1940s. Those beginnings were made 25 or 30 years before a major market penetration was achieved. Even where technologies and use have been demonstrated (for example, the co-generation of heat and electricity, and the use of district heating systems), the institutional and infrastructural changes which are needed to extend their commercial use in Canada will take many years. Before those changes are actively embarked upon, the economic and social acceptability of the new patterns of supply and use must be demonstrated. Much the same situation exists for the more profound structural and organizational changes which will be required to move conservation and increased efficiency in the use of energy beyond the first, fairly straightforward measures.

The processes of adjustment are further complicated by the increasing attention which must now be placed on environmental and health concerns, land and water use, property rights, local and

special interest concerns, institutional and regulatory processes, alternative lifestyles, and public participation more generally. The increase in emphasis on these matters is an essential feature of future energy, economic and social adjustments. Much more effective ways are needed to incorporate them into the decision-making process well in advance of project implementation and in ways which do not cause unnecessary delays, uncertainties or subsequent changes in programs. The magnitude of the increasing concern over these matters is such that it constitutes a new dimension in the adjustment process. Long-term and interim objectives and performance targets seem to be inevitable constituents to long-term adjustments. A wide array of adjustment factors must be targeted and acted upon at the same time. The next 25 or 30 years is a very short time over which to make so many fundamental changes. An essential assembly of them might be just manageable if a comprehensive, systematic and coordinated advance can be undertaken from now on, but the objectives and targets must be clearly perceived and generally agreed upon.

It is important to recognize that many beginnings are already being made, and strategies have been developed to bring about some of the necessary adjustments (Appendix 4). Significant beginnings are evident in energy conservation and in the increase in energy efficiency particularly in motor vehicles, space heating and in the industrial use of energy. Intensive efforts are being applied to bring on new supplies of oil and natural gas, to increase the use of coal and hydro power, and to work out more appropriate energy pricing and financing arrangements. Environmental and land-use concerns are being addressed, and exploratory steps are being taken to test the potential contribution of renewable energy resources, byproduct and waste energy sources. Extensions of energy systems are being examined as a means of dealing with serious regional imbalances. Nuclear power is increasing as a share of energy supply, and more advanced nuclear technologies are under investigation. Research and development, though still of modest amounts, is proceeding along identified priority lines. Public awareness and public participation in energy matters are being encouraged, and greater international cooperation and coordination are being achieved. Targets to limit the rate of growth in the dependence on imported oil have been set in Canada and in most other major industrial countries.

Initiatives such as the above are an impressive response, in so short a time, to the changing energy circumstances. They demonstrate a capacity for flexibility and resiliency and some appreciation of the extremely difficult transformations which lie ahead. This "Energy Futures" report draws attention to a number of additional programs and targets, new approaches to the adjustment process, and new perceptions and participation. Four essential extensions of those efforts are deemed to be essential in Canada if the process of adjustment is to be successful between now and the year 2000:

- Specific constraints need to be addressed in ways which recognize that major institutional, regulatory, managerial and organizational changes will be needed to construct what is, in effect, a substantially new energy system.

- The present beginnings need to be extended into a comprehensive and coordinated approach to bring together the required programs of action from their dispersed origins so that they can be assessed in an integrated manner, and targeted on objectives for the longer term future.

- The focus of attention should not be just on the difficulties and the constraints. Attention should also be focussed on the opportunities to use the transformation of the energy system as the basis for an imaginative, dynamic approach to new industrial strategies, new economic and social development, and enhanced individual well-being for Canadians. Only if the broader, long-term economic and social objectives are the basis of the transformation can the energy adjustments be successfully carried out.

- Much greater public awareness is required of the distress and disruption which can result if widespread adjustments are not supported in all parts of the country -- the costs of doing very little are high. The necessary awareness can be built up if the public can identify with and participate in the extensive initiatives which must be taken in all parts of the country.

Indicative achievement targets will help to focus the initiatives, and will help to establish the timing and staging of projects within established priorities. The establishment of objectives, targets, priorities and programs requires a recognition that the future is anything but certain. Uncertainties and risks must be accepted and provision made for flexibility, modification and resiliency. Central controls and emergency allocations will generally be unnecessary on a large-scale if effective coordination of projects and participants can be developed -- a most difficult task. Increasing government intervention seems inevitable in respect of energy pricing and financing; over exports, possibly over imports; over utility policies and management; over land and resource use, environmental and health considerations and local community interests. These are among the most strategic components of the long-term energy system. It is essential that the interventions be fully coordinated within the government sector and between government and industry, and for government, industry and the public at large. Some tentative consensus of objectives, targets and programs is required.

The reaching of consensus, the coordination of programs, the avoidance of emergency allocations and the establishment of responsible public participation will be greatly facilitated by the

publication of national (and provincial or regional) energy accounts and targets. The targets will assist in staging various programs over the next 25 years to avoid bunching and conflicts, and they will help all of the diverse participants to plan their own inputs to the programs in the most effective manner. The long-term energy targets also serve another purpose. They lay down tentative expectations and "flight paths" along which progress is to be made toward the achievement of satisfactory, sustainable energy balances. Circumstances will change. The impact of every major deviation can be assessed within the scope of the established long-term energy program. Frequent re-assessments against explicit targets will increase the resiliency of the entire energy system and help with the inevitable revision of plans and programs. Thus, interim performance targets also are essential. These would provisionally establish anticipated achievement over 3 to 5-year intervals throughout the next 25 years (e.g. 1982, 1985, 1990, 1995, 2000) and in more general terms to 2025.

Decision-making process

Without a capacity for integrated, long-term decision-making, unperceived crises are likely to emerge with increasing frequency and severity. A bewildering network of decision-making requirements, therefore, underlies a successful adjustment process. Not least of these requirements is a re-ordering of institutional and regulatory impacts to ensure that they fully support energy-related programs.

Expanded role for the private sector

When analyzing the adjustment process and decision-making, there is a tendency to concentrate on government policies, government institutions and regulations. Unquestionably, government participation in energy decisions and programs can be expected to increase appreciably. However, the role of the private sector will remain of fundamental importance to a satisfactory energy future. The traditional requirements of decentralized decision-making by private enterprise will be greatly expanded and very much modified.

The skills which are assembled in a host of large and small companies throughout the energy-related sectors will be put to new tests. Financing large-scale projects and new, experimental ones, establishing pricing and marketing policies, finding, producing and marketing energy resources, evaluating new opportunities and the pace of their development, developing new technologies, competing for different allocations of manpower, materials, equipment and earnings, accepting unknown risks, delivering the entrepreneurial and management skills through isolated, independent decisions and in concert with others will test the skills of private enterprises across Canada. Opportunities will exist for

new enterprises, often small and local, to start up in untried or unproven energy-related activities. Management and labour will be called upon to address a new range of public concerns about the objectives, priorities and operating methods of private enterprise. Many of those concerns, as well as an expanded range of other corporate activities, will require much closer working relationships with governments and other public or special-interest agencies. Energy-support industries will likewise be called upon to undertake many new, often high-risk ventures.

Much of the criticism for energy crises and energy problems often is laid at the door of one part of the industry or another. However, all of the basic requirements and problems of change would remain in undiminished form if taken over by any other ownership and control. A great array of additional difficulties would emerge. Canada for the most part, has been well served by a diverse array of companies which fit somewhere within the complexities of the energy system. These range from associates of some of the largest, multinational, integrated oil companies to large, provincially-owned utilities, through a multitude of small supply and service establishments. Many opportunities will exist to expand the range of energy-related activities across Canada. The most imaginative and vigorous efforts will be required from private enterprises, both large and small. Fundamental modifications will be increasingly necessary in the processes of private enterprise and in its relationships with governments, the public and the international community.

New responsibilities for industry

- develop the technologies to produce and market a new range of resources (e.g. solar, biomass, Arctic production and transport, oil from in situ oil sands); develop the markets;

- participate fully in developing new energy costing and pricing systems;

- develop new methods of financial intermediation both innovative small-scale and for large-scale energy projects and for the new, unproven energy resources; develop new risk-sharing techniques;

- increase energy efficiency in industry, transport and space heating;

- investigate thoroughly the industrial and manpower opportunities associated with the evolving equipment and supply requirements of the energy sector in the use of energy resources in Canada and abroad;

- develop new management and coordinating techniques for large-scale energy projects and for integrated sub-systems;

- improve methods of dealing with public concerns and public participation in energy decision-making;

- take new management initiatives for industry/government cooperation in energy and industrial developments, and in new forms of ownership and control; and

- participate in energy consultative and information systems with a view to more comprehensive and integrated energy programs.

Greater industry-government interface is being driven by many factors. Among these are: pricing and taxing policies; large-project financing; resource exploration and development; environmental and other public concerns, and the need for more concerted and comprehensive energy R&D and long-term energy assessments. Panarctic Oils Ltd. was an early example of a corporate structure which was designed to bring industry and government together in joint energy project. Petro-Canada Inc., the Alberta Energy Corporation, and the Alberta Oil Sands Technology and Research Authority (AOSTRA) are more recent examples of the increasing industry-government interface. A strategic issue area is identified for much further investigation in the changing role of the private sector and of the new requirements of the industry-government-public interface.

Risk-taking and decision-making

Risk-taking is always part of the decision-making process in the private sector and by governments. The costs and risks of being marginally overbuilt in energy supply (if that is in fact possible) are inconsequential compared with the disruptions which would arise from being underbuilt. Moreover, export markets almost certainly will be available to take up any temporary surpluses. Particularly in times of great transformations and substitutions, scope for resiliency to offset miscalculations or unforeseen difficulties must be included in the system. Two contradictory features of decision-making in the new circumstances are especially noteworthy:

- the increasing complexities and uncertainties of decision-making make it prudent to wait as long as possible before making major commitments of resources; and

- the magnitude and difficulties of many of the projects require long lead times so that decisions should be made well in advance of required energy delivery.

The flexibility and resiliency of short-term, quick decisions must be accommodated within the need for long lead times in which comprehensive assessments can be made; careful development of technologies can take place; improvements in efficiency are introduced, and the physical, economic, social and institutional constraints are cleared out of the way.

Two other features also complicate the decision-making process:

- the ownership and development of energy resources is greatly decentralized among governments and industries with very different motivations and priorities; and

- an increasing number of participants are involved in the decision-making process.

Overcoming the decision-making constraints by a systematic approach will make a major contribution to satisfactory energy futures.

Specific components of the adjustment process

The achievement of satisfactory, sustainable, long-term energy balances requires that many specific factors be brought together. These factors pertain to the following categories of the adjustment process:

- structural adjustments to demand;

- resource availability and deliverability;

- technological capability;

- economic attractiveness;

- institutional regulatory, and management capability; and

- social acceptability.

The following specific areas of the adjustment process are outlined in the following chapters:

- energy prices and pricing (Chapter 9);

- financing, ownership and control (Chapter 10);

- technology, research and development (Chapter 11);

- environmental, health, land-use and other social considerations (Chapter 12);

- institutions, regulations, administration and management provisions (Chapter 12);

- manpower, equipment, materials and infrastructure (Chapter 12);

- information, communications and participation programs, including energy accounts, targets and programming (Chapter 12); and

- recommended action programs (Chapter 13).

9. ENERGY PRICES AND PRICING

Chapter guide

- *Prices continue to hold the key to energy adjustments. In the world of the future, we won't be able to have both low energy prices and an adequate supply, or a satisfactory balance of energy.*

- *Price changes should assist in meeting four fundamental objectives:*

    a) *decrease and modify energy demand;*

    b) *increase energy supply;*

    c) *induce the substitution of other energy resources for oil; and*

    d) *support enhanced economic and social well-being for Canadians.*

- *Although the world real price of oil is expected to double before 2000, the possible absence of significant increases in the next few years will delay reductions in demand and the substitution of other energy resources for oil.*

- *Energy prices in Canada should follow world energy prices up, at least until costs of production of the energy resources which are needed for sustainable self-reliance are below world prices.*

- *A wide array of domestic energy resources can be competitively priced relative to world oil prices by 2000. Canada might, therefore, be in a favourable comparative position in respect of energy in 10 to 15 years, and energy prices in Canada can be established fairly independently of world oil prices, except for export considerations.*

- *The price of electricity (particularly produced from nuclear power) might be the competitive price setter for many uses by 2000.*

- *It is important that price differentials among energy resources support the fundamental objectives of substitution of other fuels for oil.*

- *When price increases yield windfall gains, the gains should be used in large measure to support the next stages of the energy transformation; ("windfall gains" must be assessed not just in terms of past costs but also in terms of future investment requirements, risks and expected returns on investments).*

Chapter 9. ENERGY PRICES AND PRICING[1]

Prices are the principal allocative mechanism of a market economy. They are, therefore, major determinants of what adjustments will be made and of when and how the adjustments will take place. Any substantial change in the level of energy prices or in the price differentials between one form of energy and another will have appreciable, long-term impacts on the energy system, on the economy, on Canadian society, and our international relations. Significant changes in energy prices have been underway since 1973, but energy prices and pricing policies are expected to undergo greater and perhaps more disruptive changes over the next 25 years. The impacts and the adjustment processes associated with energy price increases, therefore, are only beginning.

To meet the objectives of this long-term assessment, three principal pricing targets are set down. Taken together, they require very complex pricing relationships. The targets are:

- allow energy prices in Canada to increase in step with world prices, at least until the cost of production of the energy resources in Canada which are needed for sustainable self-reliance are below world prices;

- appropriate pricing differentials are to be encouraged to induce the substitution of indigenous resources for oil, particularly for imported oil, and do so in ways compatible with provincial or regional supply capabilities; and

- energy prices and price differentials should support competitive advantages for Canadian industry.

The above pricing targets support the general objectives of reduction in energy demand, increasing the supply of Canadian resources, and the substitution of indigenous resources for imported oil. Given that array of objectives and the complicating factors noted below, it is not surprising that "energy prices and pricing" constitute a strategic issue area for which considerable further investigation is recommended. This present assessment, for example, does not go into the analysis of price elasticities under the very different and uncertain conditions of changing prices, relative prices and increasing pressures of demand.

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1 Some observations on the prices of specific energy resources appear in Chapter 5.

Principal pricing changes

The following are among the principal price and pricing changes which are expected to affect the achievement of satisfactory, long-term energy balances:

- The world price of oil is expected to at least double in real terms by the year 2000, although only moderate real price increases might be experienced over the coming 5 years. By the year 2000 (or sooner), world oil prices will have become sufficiently high that energy resources will be able to be produced and marketed in Canada, in substantial quantities, from a range of domestic sources at prices below the world oil equivalent. At that time, the world oil price will cease to be the principal reference price for energy in Canada. However, the absence of significant further increases in world oil prices in the near future will delay the essential adjustments unless other incentives are provided.

- Oil prices in Canada will tend to follow world oil prices up at least until the level is reached at which oil can be produced and marketed in significant quantity from Canadian "high cost" reserves at prices which are then lower than the landed price of world oil.

- The prices of other energy resources in Canada will tend to move up on a thermal-equivalence basis with oil at least until they, too, reach a level at which significant quantities can be produced and marketed at prices lower than the world price of oil; however, adequate price differentials are to be encouraged which will induce the preferred patterns of energy supply and use.

- The sharply higher energy prices will do much to moderate demand, encourage conservation and increase the efficiency with which energy is used. However, the delay in price increases will delay this inducement to lower energy use; higher energy prices will later be accompanied by increasing distress among low-income recipients and for some businesses unless offset, where appropriate, by income supplements or other adjustment assistance.

- Virtually all alternative energy resources in Canada might be in a favourable, competitive price relationship with world oil by the year 2000. A number might reach favourable price relationships much earlier. Natural gas, electricity from hydro and nuclear generation might be among the first to achieve favourable price relationships. However, if most natural gas supplies by that time are coming from Arctic and other frontier regions, the price of natural gas might remain close to the thermal equivalence of oil into the 1990s or even beyond the year 2000.

- As these various price increases occur, windfall gains over current costs of production will appear. Great care must be taken to ensure that those gains, however distributed, support the much greater financial requirements and the greater risks of the energy sector in the future.

Hydro-electricity will face practical limits to supply because of the few remaining, remote and high-cost sites beyond about 1995. Nuclear power, therefore, might emerge as a price-setter for new energy uses. By 1990 or soon after, the "nuclear kilowatt-hour" of electricity might replace oil in many uses in Canada as the competitive, reference energy price. Further observations on electricity pricing are made in a subsequent section of this chapter.

A number of other forms of energy might be favourably priced by 1990 or before. These could include, for example, some forms of biomass, solar and tidal power, co-generation and other byproduct forms of energy. Peat, urban waste, hydrogen and SNG will all reach more favourable price relationships as the world price of oil increases. However, their market penetration will be limited by the competitive prices of other Canadian sources of energy, and by the sheer managerial and organizational difficulties of bringing these new energy forms into substantial use in so short a time.

Price changes beyond the year 2000 are expected to support more moderate, further adjustments in demand, increases in supply of energy resources, and more readily accommodated substitutions among them. Hence, the most critical price adjustment are expected to occur between now and the year 2000. Automatic adjustments to price stimuli cannot be expected. The complicating factors which can distort or blunt the favourable adjustment impacts of energy prices include the following:

- Energy prices are very largely controlled or "administered" by governments in Canada and abroad, or by producing or marketing organizations. A number of objectives are being served and a number of unintended impacts will result which can distort the adjustment process. Some of these factors are outlined below.

- There is a pronounced tendency to price energy resources up to the thermal equivalence of the highest cost source (usually, at present, world oil) rather than price it in conventional market terms at costs of production plus a "normal" profit. For many energy resources, thermal-equivalence pricing permits a windfall gain (an economic rent) to be collected somewhere in the process. However, the tendency toward price parities blunts the incentives for interfuel substitutions which would result if some energy resources (e.g. natural gas, electricity, and perhaps coal or biomass) could establish clearly lower market prices.

- Care must be taken that a so-called "windfall gain" is not removed entirely from supporting essential future energy financial requirements. At times of rapidly rising costs of investment and operation, it is extremely difficult to assess accurately what, in fact, is "windfall gain". In recent years, provincial governments have attempted to collect a substantial part of the windfall gain as taxes, royalties, or other levies. Whatever might be the merits of that policy, when viewed in terms of provincial resource ownership or provincial "social justice", it could hinder adequate future financing of energy programs, including those needed to achieve interfuel substitutions. On the other hand, if the windfall gains were left entirely with the producing companies, or passed back to workers or other factors of production, or passed on as subsidies to consumers, other distortions could take place. A further difficulty is that such "distortions" are necessary signals for long-term adjustment. The essential requirement for energy policy purposes is to ensure that, however the revenues which result from higher energy prices are distributed, they do support the long-term energy objectives.

Following the initial, severe and disruptive tax and royalty changes after the 1973-74 OPEC oil price increases, the federal and provincial governments reached agreement on the inter-relationship of their fiscal systems, and greater incentives were returned to the exploration and production activities of the oil and natural gas industries.[1]

Substantial changes in provincial and federal tax and royalty structures affect the prices paid for energy by the users and the rates of return to producers. Both of these impacts can have a great effect on the demand for energy, the availability of resources, the pace of development of one resource or the demand for it in relation to others, and, hence, on the achievement of long-term energy balances. Many objectives must be served by the tax and royalty policies of government. In this assessment, a dominant consideration for provincial and federal fiscal policies is to ensure that they fully support the objectives of sustainable energy self-reliance in Canada over the long term. Perhaps in no other area of federal-provincial energy relations is coordination and agreement of policy for national purposes more obviously essential.

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1 Outlines of the fiscal and revenue changes can be found in "An Energy Strategy for Canada", op. cit.; and "Canada's Resources and the National Interest", by an Independent Task Force on the Crisis in the Development of Canada's Mining and Petroleum Resources, initiated by the Canada West Foundation, Calgary, January 1977; especially Appendix A, "Taxation of Non-Renewable Resources" by Price-Waterhouse and Associates.

- There is no assurance that price signals will be timed consistently with the long lead times required for the adjustment processes. A clear price signal often is required at least 10 years in advance of the significant impact which is to occur in energy demand or supply. At best, much of the intervening time could be very stressful and disturbing. A sudden, sharp price increase late in the period, or a number of confusing and contradictory price signals during the period, would add greatly to the difficulties.

- Among the "other considerations" which get built into administered prices are subsidies to cushion the shock of rapidly rising costs, and attempts to take into account external (or social) costs and benefits which have not been part of the traditional pricing process.

  Subsidies can be applied to protect consumers, particularly low-income householders, from the hardship of rapidly rising energy prices or to assist them in energy conservation (for example, the federal government's CHIP program for home insulation). Subsidies can also be applied to protect the competitive position of industries from sharply increasing energy costs. Subsidies, possibly in the form of favourable tax provisions, can be provided to producers to bring on particularly high-cost or risky energy supplies (for example, oil sands, heavy oils and frontier oil production). Subsidies tend to distort or blunt the long-term energy adjustment process. Their purpose within the total adjustment process needs very careful assessment. Protection of low-income consumers against sharply rising costs (whether energy or other) typically can be more effectively carried out by selective tax and income-support policies. Industrial subsidies, through lower energy prices, likewise are not tailored to those industries which are especially vulnerable. Taking a longer view, energy costs in Canada are expected to be <u>below</u> those in many other industrial countries, at which time subsidies should generally not be necessary. In the meantime, essential adjustments to demand and supply should reflect the higher energy prices and the price differentials which can be established among different energy resources. The shock and the impact are necessary for adjustments to take place.

  Attempts to build into energy prices additional cost factors for "external" or "social" costs typically are made by "internalizing" such elements of costs into the company's or industry's operations. This might be done by a specific levy, for example, for environmental protection measures, or by a requirement that corrective, capital equipment be installed. (There might also be external, or social, benefits which also should be taken into account.) External costs, so accounted for, will tend to be passed on in higher energy prices. They will, therefore, have the same general effect as any other

increase in energy prices. They can also create further distortions in the adjustment process because the external cost additions are likely to differ appreciably from one energy source to another. Some of the differences might be fairly arbitrary, representing particular institutional or regulatory factors.

- Differences in provincial and regional potentials and priorities also are highly relevant considerations in any assessment of appropriate energy prices, price differentials and pricing policies. If, for example, an increase in the use of natural gas is to occur in space heating in Quebec and the Atlantic provinces, natural gas prices should encourage that choice. The price differentials with electricity or with the residual oil from oil refineries will have a significant impact on the respective attractiveness of these three sources of space heating.

- The prices of energy resources in other countries and of those energy resources entering international trade will have important impacts on prices in Canada and on Canada's international trade in energy resources and industrial products. On balance, Canada might expect to achieve a competitive advantage in energy prices among the major industrial countries by 1990 and beyond. Satisfactory energy balances could thus provide substantial new opportunities for Canada's international trade in energy resources and in industrial products with a high embodied energy content. Thus, energy price considerations will be explicitly brought to bear on the objectives and targets of Canadian trade and commercial policy.

- Two other pricing considerations which are receiving much current attention are: marginal cost pricing and "two-price" systems. As with other aspects of pricing, these are related closely to the financing and the financial attractiveness of energy projects.

  Marginal cost pricing recognizes that, under current conditions of rising costs, there will tend to be a cost-price squeeze unless prices are increased to cover fully the higher-cost additions to supply. On the other hand, if the price of all units of supply are raised to the higher cost increments (which, for a time, might be only a small part of total supply) the effect will be a substantial increase in earnings. The price to the user will be higher than necessary to cover the average cost of all production up to that point.[1]

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1 A different "marginal price" concept relates to energy demand. In this approach, a user would be charged a higher price for larger quantities consumed, thus providing an incentive for energy conservation. See "Electricity rates and pricing" below.

There are a number of ways to accommodate the difference between high, "marginal" (or incremental) costs and the lower, average cost of all units of production. One way is to introduce a "two-price" system in which the price of the existing supply remains unaffected by the higher costs of the additions, and the user of the new, higher cost supply pays a higher price. Many difficulties relate to the application of a two-price system and to its effect, depending upon how it is applied. Among these are why a particular use or user should be penalized by the higher price. Another is how, within a general source of supply such as electricity from a provincial utility, the higher priced, incremental supply is to be "folded into" the general rate structure.

An example of the application of the two-price system is contained in an assurance given to Syncrude Canada Ltd. that the oil produced from its oil sands plant would be priced at the appropriate world level even if, by the time the oil sands production begins, oil prices generally in Canada have not yet obtained that level.

The introduction of marginal cost pricing and two-price systems are only part of the overall price considerations. They do not offer any unique solutions to energy adjustments which are to be brought about by price changes. These two pricing mechanisms represent additional forms of "administered" prices which might contribute to satisfactory energy adjustments if the comprehensive energy objectives, as well as the specific resource objectives, are kept clearly in mind.

Behind all of the additional considerations which price mechanisms are called upon to absorb remains the basic market function of pricing to bring into production and to market those energy resources which can be most competitively priced to meet an array of demands. It is important that attention is focussed on that objective.

Electricity rates and pricing

Sharply rising fuel and capital costs have produced a dramatic change in the cost-price relationships of electric utilities. Most electricity is produced in provincially-owned utilities. These have public rate (or price) structures that can be increased only with the approval of a provincial board or commission. Until recent years, the unit costs of producing electricity tended to decrease or to increase only moderately, thereby encouraging more and more use of electricity. Following the sharp increases in oil prices and of capital costs in recent years, unit costs of electricity have risen sharply. This has led to increases in electricity rates of as much as 50 per cent in one year or, in some instances, over three or four years. Even with these rate

increases, many utilities face difficult operating and capital cost situations and a number of provincial governments, and the public, are expressing concern over the mounting debt and financial requirements of the utilities.

A significant difference in the cost structure of electrical utilities is that the unit cost of thermal generation from oil and coal is heavily affected by those fuel costs whereas, for hydro and nuclear generation, cost structures reflect more heavily the capital costs of installation. Rapidly increasing fuel costs and expectations of further increases tend to favour installation of hydro and nuclear facilities. On the other hand, with capital costs also increasing rapidly and the financing of large-scale, capital projects difficult to arrange, there are incentives to add smaller increments to generating capacity by the addition of coal or oil-fired generators. Smaller increments might also seem prudent when rates of increase in demand are expected to moderate, perhaps appreciably. On balance, over the longer term, the expectation is that nuclear and hydro generation will provide by far the largest, and most cost-effective, additions to electrical generation. By the year 2000, favourable hydro sites will be largely harnessed. Future large-scale expansions of generating capacity beyond 2000, are likely to be based principally on nuclear and coal, with tidal, renewables, byproduct and waste product resources also coming increasingly into use. Provincial variations are not expected to alter the relationships in any fundamental way.

The effect of these structural changes in electricity generation is expected to be a continuation of significant price increases over the coming 10 years. Beyond that time, price increases might moderate and the price of electricity become increasingly competitive with oil and natural gas for many uses. In the longer term, electricity prices might set a competitive reference base around which other energy resources will tend to orient. Within the general pattern of price increases for the electrical utilities, additional problems of adjustment arise concerning rate structures. A re-examination of rate structures is encouraged by considerations such as the following:

- the marginal pricing problems noted above;

- the need for more internal financing and more debt servicing by utilities; and

- the need for conservation and greater efficiency in the use of electricity.

Two characteristics of existing rate structures are receiving particular attention:

- Low, "bulk" rates provide for lower unit prices as the quantities of electricity consumed increase. To discourage the use of electricity, that structure might be reversed -- a higher rate be applied as more electricity is used. However, especially in industrial uses, the unit cost of delivering electricity generally declines as the quantities which are used increase. This is especially true if the bulk use occurs during off-peak hours or seasons, or if the supply is interruptible to meet other more urgent needs. There is an element of inequity in collecting a larger marginal revenue from users who often, by the nature of their business, require large quantities of electricity which can be delivered by the utilities at decreasing incremental costs.

  A separate provision might be introduced on an individual metering basis to encourage individuals to reduce the amount of electricity which they use, and to spread the use to off-peak hours as much as possible, perhaps by using heat storage systems.

- Lower off-peak rates can be provided to try to spread the use of electricity more evenly throughout the day (or year). Generating capacity is required in sufficient amount to ensure that peak loads can be always met. If the load could be spread more evenly, the amount of generating capacity required to meet the peak would be reduced, as would the inefficient idleness of generating capacity during off-peak hours. Part of the change, under the incentive of lower, off-peak rates, could be induced simply by changing personal living habits. More substantial structural changes can be made by using electricity and heat storage equipment, heat pumps and other forms of heat exchange systems, and perhaps by calling in smaller peaking generators based, for example, on biomass, district solar systems, or co-generation.

Changes in rate structures gain additional significance from the ways in which they support or detract from an expanded electrical option, or affect the structure of the economy and of society. Periods of uncertainty, controversy and testing of new approaches can be expected. Case studies and pilot projects could assist the adjustments particularly as these differ from one province to another.

Prices summary

It is apparent from the above that a host of factors are to be considered when assessing the impact of future energy prices on the adjustment process. Substantially higher energy prices will, for the most part, be the principal factor supporting the achievement of satisfactory energy balances along the lines of this report. Also of first importance are the differentials in prices

Capital investment in energy equipment will require much greater financing — supported in large measure by higher energy prices.

to encourage substitution away from oil and toward other energy resources, particularly those indigenous to a province or region. However, the various price factors and the probable delay in the price increases will pose serious difficulties within the adjustment process. Additional uncertainties occur in the tax and other fiscal policies of the provincial and federal governments. Their intended and unintended impacts on energy resource development and on other elements of demand and supply are seldom fully assessed and explained, particularly within the context of longer term expectations.

Energy prices in the future will be substantially administered, and will contain provision for factors which traditionally have had little impact on market prices. Clear and systematic evaluation and coordination of the complex pricing regimes is, therefore, an essential feature of the long-term adjustment process. Prices and pricing policies must clearly support the attainment of satisfactory and sustainable long-term energy balances and be understood to be so supporting.

10. FINANCE, OWNERSHIP AND CONTROL

Chapter guide

- *Financial requirements for the energy sector will increase significantly as a proportion of Canada's total investment and as a proportion of gross national product.*

- *There will be no easing off but rather a further increase in financial requirements for energy beyond 1985. The financing targets call for energy-related investment to average close to 6 per cent of gross national product from 1978 to 2000, and possibly 4.5 per cent from 2000 to 2025. The average between 1950 and 1975 was about 3.4 per cent.*

- *Substantial changes in the nature of energy financial requirements will necessitate innovations in the sourcing of funds and in the intermediation processes.*

- *Although most energy financing and most of the financial services will be done within the private sector, government financial participation will increase appreciably.*

- *Sizeable capital inflows from abroad likely will be necessary, but under different conditions of ownership and control.*

- *The coverage of energy and energy-related projects to be considered for financing will be much broader than the conventional supply projects.*

- *Some form of revolving energy investment fund, joint ventures, and new approaches to financial consortia and intermediation could be significant in future energy financing.*

- *Taxes and royalties and similar government levies will play an even greater part in the allocation of energy investment funds in the future.*

- *The commitment of funds by large multinational companies, by provincial utilities, and by large-scale energy customers in Canada and abroad will undergo considerable change in ways which might increase the difficulties of energy financing.*

- *New opportunities and, indeed, requirements will emerge for increased Canadian participation, ownership and control.*

- *Some existing links between financing, ownership and control will be weakened.*

Chapter 10. FINANCE, OWNERSHIP AND CONTROL

The achievement of satisfactory energy balances over the long term is closely tied to the financial attractiveness of a new array of energy programs. Financing will be required not only to bring into being, with appropriate timing, large-scale projects many of which are novel and high-risk (heavy oils, in situ oil, Arctic transport, new nuclear technologies). Large financial capabilities must also be forthcoming for new energy forms (solar, biomass, co-generation, etc.), for extensive conservation efforts, structural changes in demand, and environmental and other social-impact activities.

Three principal characteristics affect the achievement of those objectives:

- financial requirements for the energy sector will increase very substantially and will tend to call for an increase in foreign capital inflows;

- substantial changes will take place in the nature of financial needs, in the sourcing and management of funds, in the nature of risk, and in the attendant conditions surrounding their availability and use of funds; and

- government supervision and direct participation in financing, ownership and control will increase.

How much financing? For what?

The Strategy report and the subsequent support paper on energy financing[1] estimated that the total amount of capital required by the major sectors of the energy system to 1990 would be in the order of $180 billion (1975$). That total was made up of the principal components shown in Table 10-1.

A larger requirement for electricity generation, or for a number of other projects, than shown in Table 10-1 could result in total energy-related capital requirements well in excess of $200 billion from 1976 to 1990. The 5.2 per cent average rate of energy investment to GNP contains a 5-year average rate as high

1 "An Energy Strategy for Canada, Policies for Self-Reliance", and "Financing Energy Self-Reliance", Report EP 77-8, Department of Energy, Mines and Resources, Ottawa.

TABLE 10-1

Estimated Energy-related Capital Requirements, 1976-1990*

(billions of 1975 dollars)	
Electric power	$110.0
Pipelines	16.7
Petroleum (oil and gas)	
Exploration and development	23.3
Refining and marketing	12.9
Oil sands	14.8
Coal (ex. new transport)	3.3
Total energy above	181.0
Percentage of estimated GNP	5.2%

* Assumes a greater emphasis on oil sands, heavy oils and electricity than would be the case if frontier oil and natural gas reserves were discovered and more rapidly brought to market.

as 6.5 per cent between 1980 and 1985, with a decline to an average rate of 4.2 per cent from 1985 to 1990. The share of capital outlays for energy relative to total capital investment in Canada, which has averaged about 15 per cent, would increase to an average of about 23 per cent between 1976 and 1990. As a share of GNP, capital expenditures on energy were expected, in the Strategy report, to be especially high between 1980 and 1985, then gradually decline to lower ratios between 1985 and 1990. Although the above percentage of energy financing to GNP is high by historical standards, it was not considered to place undue strains on the ability to attract funds from sources in Canada and abroad.[1]

In extending the analysis of the capital requirements of the energy sector beyond 1990, this "Energy Futures" assessment anticipates a continuation of substantial energy investments from 1985 to 2000. Moreover, the ratios remain relatively high after 2000,

1 A number of these considerations have been further elaborated upon by J.R. Downs - "The availability of capital to fund the development of Canadian energy supplies" - Canadian Energy Research Institute, University of Calgary, Calgary, Alberta - Study No. 1, November, 1977.

but fall off from the peak levels obtained between 1990 and 2000. An indicative target of 6 per cent of gross national product has been set for the years 1978 to 2000, and 4.5 per cent for the years 2000 to 2025. As a result, the investment requirements of the energy sector in the ten years from 1990 to 2000 could be greater in absolute amounts (in 1975$) than the requirements in the 15 years from 1975 to 1990. In addition, a further array of energy-related investments will be needed that are not explicitly provided for in the earlier analysis. Gross national product, by the estimate in Chapter 4, would be $375 billion (1975$) in the year 2000. If investment in energy amounted to 6 per cent of GNP, it would be $22.5 billion at that time, compared with an average of $12 billion to $14 billion a year for 1986-90 in the Strategy report estimates. That is a substantial, but probably a manageable, increase if the financial services are adequately organized.

In planning investment and the sourcing of funds, it is also necessary to carry out assessments in current dollar terms, not just in constant dollars. Different rates of cost and price increases throughout the energy system can greatly affect rates of return, discounted cash flows and the relative attractiveness of one energy investment in relation to investments elsewhere in the energy sector, in the Canadian economy, or abroad. A further consideration is the extent to which financing provisions will be deliberately used to develop energy resources selectively in order, for example, to encourage expansion of indigenous resources in energy-deficit provinces or regions. Differential developments are likely to require different discount rates for new investment, differential tax, price and rate-of-return provisions, as well as different ownership, management and institutional arrangements.

The higher energy investment beyond 1990, though probably manageable with sufficient financial innovation, will not be easy or automatic. Substantial difficulties are anticipated well before 1990 in providing the incentives and the appropriate financial intermediation services to ensure that the funds are, in fact, available when and where they are required within the energy sector. Some intimations of those difficulties are already evident in the financing of large-scale energy projects. The difficulties can be expected to increase appreciably. Beyond the energy investments which are included in the historical aggregates of capital expenditures, a large number of additional types of energy-related investments will call for financing. These include, for example:

- Capital expenditures for the production and marketing of renewable and similar resources (biomass, solar, wind, tidal, geothermal and peat).

- Byproduct energy sources (co-generation, co-production, use of urban, industrial and agricultural wastes and heat discharges from public utilities).

- Conservation, efficiency-increasing measures and structural changes in energy demand.

- New energy forms -- for example, LNG, SNG, methanol and synthetic liquid fuels, hydrogen, methane from coal fields, the organic-cooled nuclear reactor and the thorium-fueled nuclear reactor. A number of other new, energy-related investments are outlined in the following paragraphs.

It was noted in Chapter 5 that the renewable resources might supply the equivalent of 5 per cent of Canada's primary energy needs by 2000 and 10 per cent by 2025. The 5 per cent by 2000 is more than four times as much energy as now supplied from Canada's nuclear plants, or the equivalent of about three oil sands plants. Even assuming that capital requirements per unit of energy output were only one-half those of oil sands plants, or of nuclear plants, the capital investment in renewable energy resources might be of the order of $15 billion to $20 billion (1975$) over the next 25 years. That investment does not include all of the other new or expanded forms of energy resources in the above examples.

Substantial investments will be required in the energy-support industries (transportation and transportation equipment, earth-moving equipment, metal fabricating, machinery, electrical and electronics equipment, plastics and petrochemicals). Further extensive expansions also will be required in infrastructure systems and community development across Canada. Additional investment outlays also will be required in pilot and demonstration projects to test new energy supply and conservation possibilities. These will extend to experimental projects of significant size, for example, new types of vehicles, transit systems, Arctic transport, climate-controlled, enclosed commercial centres, district heating systems, building and community design, nuclear power systems, and integrated energy systems (combinations of energy resources, for example, forest waste, reclaimed oil, local electrical generating facilities, industrial and agricultural energy sources).

Investment outlays will extend to new or re-designed processes and products to take advantage of the market opportunities afforded by the new energy resources, supply systems and the new forms of energy demands, as a significant part of active industrial strategies by business and governments.

No specific estimates are provided in this assessment for the additional capital investment represented by extensions to financing programs such as outlined above. It seems reasonable to expect that, in total, these investment programs will require at least one-half as much financing as the main energy projects referred to earlier.

Financing energy investment

For purposes of assessing the adequacy of the full financial system, the coverage of the energy and energy-related sectors and activities can be summarized into six broad categories.

- **Conventional energy sources but on a large-scale** -- conventional oil, natural gas, coal, electricity, pipeline projects, hydro, nuclear and coal-fired thermal electricity generation and transmission -- usually to serve national and regional markets, as extensions of conventional patterns of supply and use.

- **Frontier or other new projects** of fairly conventional resources but under extremely different, untried conditions -- frontier oil and natural gas production and transportation; extensive mapping and geological evaluations; "tight formation" natural gas, secondary and tertiary recovery methods; heavy oils and oil sands extraction and processing; electricity generation from even more remote and difficult hydro sites and from new nuclear technologies usually very large-scale, for regional and national use, and possibly some export.

- **New resources and patterns of demand** which are reaching thresholds of deployment, but which confront great difficulties regarding commercial production and marketing -- biomass, solar and wind energy, low-head hydro, new transportation modes and vehicles, co-generation, district heating, the use of byproduct energy, new design and siting of dwelling units -- often local, individually small scale, but possibly required in a great number of units for which total financing will be substantial.

- **Experimental forms and projects** which require extensive research, development, demonstration and pilot project testing -- tidal, wave power, the thorium cycle, the organic-cooled reactor, large-scale solar, new transportation and urban systems design, fluidized bed combustion, slurry pipeline, Arctic large-vessel and specialized-vessel transport, storage systems -- these projects in total may be either small-scale and local, or large-scale for regional or national use.

- **Distribution, market deployment; support industries and new industrial and commercial uses** -- equipping consumers to be able to use new energy systems or to use multi-supply systems; distribution and delivery systems to principal consumers, integration and partial replacement of existing patterns of supply and use -- these projects may be either large scale, regional or national in scope, or local and required either as one or two unique projects or in fairly standard large numbers.

- **Environmental expenditures, land acquisition, community development and re-design.**

Each of the above categories contains substantial differences from the accustomed financial processes, but with some common characteristics. For example:

- risk and uncertainty are usually high, for new technologies, for production and marketing, and for institutional or tax reasons;

- the impact of external considerations such as environmental concerns, health, public safety, land use, community development, infrastructure support is potentially great but largely unknown during project design and start-up;

- the new projects cannot be viewed as separate entities but as integral parts to a new synthesis of supply capabilities and patterns of use; they are part of a new energy system which is being rapidly changed through its anticipated productive life; and

- many more interests and decision-makers must participate in determining the conditions under which the project will come into being and operate, and the ways in which the revenues from its operations will be distributed.

Over much of the energy system, the existing financial intermediation processes by the private sector probably will continue to bring adequate funds to financially sound energy projects. They will do so, however, under increasingly complex and difficult conditions. A bewildering array of vast new projects, incorporating untried technologies, operating in unknown environmental, institutional and community conditions will be competing for access to financial markets. At the same time, comparatively small-scale projects in new parts of the energy system (renewables, conservation and efficiency, co-generation, district heating, storage, etc.) will be trying to find financial footholds with schemes ranging from highly imaginative (but often poorly organized and completely untested) venture capital requirements, to fairly routine corporate access to funds for new energy-efficient machinery, equipment, structures and processes.

Many projects will be "high risk" and the portfolios of investment institutions might well become unbalanced unless offsets or guarantees are available, typically from governments or larger financial consortia, possibly international. The timing and scheduling of projects will determine in large part the ease with which the financial markets can cope with them. The more systematic and coordinated the targeting and programming of projects, the greater the likelihood that the financial institutions, the energy industries and the governments can manage the tremendously difficult tasks.

Financing and financial intermediation will face much greater participation by all levels of governments in Canada and abroad. Government intervention will take many forms, involving many departments and functions of government -- taxes, loans and subsidies, industrial and community infrastructure, monetary and fiscal policy, regulations and controls, industrial and trade policies, immigration and employment policies, regional development, equity and loan participation in joint ventures through an increasing array of government companies or agencies, or in competing, quasi-private industry activities. The much greater share which governments (particularly provincial governments) take of total resource revenues makes it appropriate that governments should increasingly be the source of funds for energy investments. A substantial portion of those funds are likely to become available through direct government allocation, or through government sponsored companies such as Petro-Canada Inc., rather than through private financial intermediation.

Even with the greater involvement of governments in energy financing, ownership and control, private financial intermediaries are likely to find a considerable increase in the magnitude of energy-related financing which they are called upon to provide, and a changing array of conditions within which they will operate. In their relationship with governments, the energy industries and financial intermediaries will increasingly seek government assistance, advice and rulings. They are likely to feel frustrated and delayed by a complex array of government policies and bureaucratic involvement. The office of "Vice President of Government Affairs" might well become the path apparent to corporate president and chief executive officer.

In designing new financial approaches, ample opportunities should be sought to offer Canadians a range of investment opportunities which enable them to identify closely with Canada's energy future. Bold financial initiatives and innovations, therefore, are called for. An entire network of financial requirements and types of financial services is recommended for detailed assessment as a part of one of the strategic issue areas.

Oil and natural gas financing

Over 70 per cent of the financing for the petroleum (oil and natural gas) industry come from internal, corporate sources of funds, principally because of the dominant position of the large, integrated, multinational companies. The Canadian-owned, large exploration and production companies and the junior petroleum companies (mainly exploration) rely more on share issues and borrowing. In the case of the junior companies, cash flow often is maintained by selling discoveries or an interest in them. This tends to further concentrate the financing as well as ownership and production in the large, multinational companies. In the period 1970-74, the large, multinational companies accounted

for about 95 per cent of the net profits of the industry, but just under 80 per cent of the capital expenditures.[1] This reflects their heavier reliance on internally generated funds.

On the whole, internal sources of funds are expected to be sufficient to provide the major portion of financing for the exploration and production of oil and natural gas in the conventional producing areas and, possibly, in the frontiers. Changing tax, royalty, leasing and access provisions, the degree of success of exploration activities and uncertainties about prices and rates of return are likely to be more immediate determinants of the pace of development than any shortage of internally generated funds. The effect of favourable price, tax and discovery incentives can be seen in the greatly increased exploration activities in Alberta in 1976 and 1977. To date, in the frontier areas, the attendant conditions have kept considerable activity going, but low rates of discovery, high costs and some jurisdictional problems have prevented greater efforts from taking place. Much greater outlays will be required once the production phases begin.

The heavy oils and oil sands operations present a very different type of financing situation. Although production is now underway, both the heavy oils and oil sands are still at experimental stages. By this assessment, the financial commitments to heavy oils and oil sands are expected to be very substantial, possibly exceeding those for exploration and production in the conventional and frontier areas. Extraction and processing commitments for each heavy oil and oil sands project will be large (possibly $4 billion per project in 1977 dollars), and the start-up and pay-back times long. Many projects are expected to be underway concurrently after 1985 so that the internal cash flow and the outside fund-raising capabilities of even the large petroleum companies might be severely strained by commitments to the heavy oil and oil sands deposits. Even so, the commitment of funds by the large, multinational petroleum companies to oil production from the oil sands and heavy oils is expected to make up a high portion of the total financial requirements. These commitments will face competition within the companies from other large-scale ventures, including perhaps some which represent a deliberate policy to diversify operations, to some extent, away from petroleum.

Transfer of funds within the industry has long been a feature of the petroleum industry, but typically involves a small part of the total internal financing. In the future, much larger, more complex and riskier projects will be undertaken which can be expected to require more joint-funding by groups of companies, probably not all within the established industry. The increasing participation of governments will make it easier to bring together a number of participants for one large project or for a series of related projects (for example, 10 oil sands plants).

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1 See "Financing Energy Self-Reliance", Department of Energy, Mines and Resources, Ottawa, Report ER 77-8, 1977.

The larger, Canadian-owned companies, of which Petro-Canada Inc. is an example, are expected to take a significant position in the oil sands and heavy oils. The participation of Petro-Canada Inc., in effect, introduces government-supplied funds to the projects. Other forms of government funding also will likely be required, possibly through other Crown agencies, other equity financing, borrowing provisions, delayed tax payments, and possibly through a revolving energy investment fund or revenue bonds, as outlined later in this section. An energy investment fund could be used to increase participation by a number of provincial governments, the junior petroleum companies, a greater range of financial institutions, mining and construction companies, equipment-supply companies and the public at large. A portion of the government commitments to such a fund could be on a revolving basis, an early commitment (equity or debt) being sold or liquidated as production and earnings of a particular project proved to be attractive to less risk-taking investors.

Pipeline financing and other transportation

Financing oil and natural gas pipelines can be examined in three components:

- oil and gas pipelines south of the 60th parallel;

- oil and gas pipelines on the mainland north of the 60th parallel; and

- oil and gas pipelines, or other connectives, offshore in the Arctic and the Atlantic off the East Coast.

Pipeline construction south of the 60th parallel will include repairs and maintenance, looping or other increases in existing capacity, possibly converting pipeline pumps to electricity, extensions of collection networks, trunk pipelines and distribution networks (for example, through Quebec and parts of the Maritimes, possibly a similar one for oil). For the most part, in southern regions, conventional pipeline financing is likely to be adequate, although considerations such as smaller potential market expansion, the absence of large export markets, and new regulatory requirements will create financing difficulties.

Frontier pipelines -- Arctic mainland and offshore (Arctic and coastal) involve much higher expenditures per mile of pipe, and many other complications than conventional, southern pipelines. They face unprecedented economic risks, including uncertain energy reserves, the possibility of serious cost over-runs, uncertain marketing conditions because of the relatively high price of frontier oil and natural gas. Many technological problems, environmental and land-use and land-ownership problems will

continue to require solution over the coming 25 years. These will add to the delays and costs of frontier pipeline construction. The magnitude of individual, northern or coastal projects could be greater than the total capital expenditures in oil and natural gas pipelines in Canada to date (when expressed in comparable, constant dollars). Two, three or four such projects might be undertaken in the next 25 or 30 years.

In the past, much of the pipeline construction was built for oil and natural gas exports. Large-scale customers in the United States had a direct interest in ensuring that funds were available. In the future, pipelines will be built primarily for resource distribution in Canada -- in some instances, to serve relatively small and scattered markets. Different forms of fund-raising, guarantees and rates are required under those circumstances. The federal government and the governments of the consuming and producing provinces are likely to be called upon to an increasing extent to ensure the financial viability of the pipelines.

Taken in total, therefore, pipeline construction and financing in the future is by no means simply an extension of well-established practices. Much greater financial requirements, the possibility that outlays might be bunched between 1985 and 2000, and the vastly different conditions under which pipelines will be built and the oil, natural gas and other products marketed, require substantial innovations to the sourcing of funds and the ways in which they are made available.

Energy transportation other than pipelines might require capital expenditures almost as great as those for the pipelines. Marine transport by LNG tankers and barge/icebreaker combinations, extensive expansion of rail, terminal and port facilities and/or slurry pipelines for coal could all require sizeable capital outlays. Rail, road, water and air transport to remote areas to service energy developments and other projects will add greatly to transportation investment. Electricity transmission, including new high voltage DC lines over long distances, and an increasing use of submarine cables, imposes substantial additional investment requirements. To meet higher energy efficiency objectives, new urban transit systems and freight hauling systems will be called for. Some of the transportation services will be provided as part of the investment programs of the carriers -- rail, road, marine and air. For the most part, these various transportation services require (or would benefit from) sizeable technological innovations and new management systems. Government participation is a common feature of transport financing, and federal/provincial coordination of effort is likely to be called upon to an even greater extent to meet these additional transport requirements.

Electric utility financing[1]

Electric utility financing also illustrates the complex changes which are occurring as a result of factors introduced by the sharp increases in oil prices in 1973-74. The rapidly changing relationships between prices, capital expenditures, government involvement and external financing come together in a unique way in utility financing. Significant among the difficulties is the reconcilation of long-term and short-term objectives and of provincial and regional differences within a coordinated national approach.

Among the principal, increasing difficulties which confront decision-making for the utilities are the following:

- uncertainties re future increases in demand; the serious impact of overestimations of demand on shortfalls of revenue to support large-scale capital expansion, and the impact of underestimation of demand on inadequate electricity supply;

- increase in capital and operating costs relative to price increases, thereby reducing the availability of internally generated funds as a basis for external financing;

- greatly increased magnitude of capital projects relative to the external debt-raising capacities of the utilities and of the provincial governments to guarantee the external financing;

- risk associated with sizeable cost over-runs on large-scale capital projects, combined with the risks of overestimating the increases in demand;

- uncertainties re correct pricing policies to reconcile demand-management policies with cash flow requirements;

- impact on financing needs and their timing combined with increasing public concern about the environmental, land-use and the capital cost impacts of electrical generation and transmission;

- selection of the appropriate resource base for increases in electricity generation (hydro, coal, oil, nuclear renewables, co-generation, etc.) in relation to investment policy; the integration of provincial utilities with regional grids; the choice between accepting higher operating costs (especially fuel) in order to avoid higher capital costs (e.g. nuclear plants);

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1 See also "Financing Energy Self-Reliance", Department of Energy, Mines and Resources, Ottawa, Report ER 77-8, 1977.

- development of electrical generating capacity to accommodate demand substitutions away from oil;

- desirability of encouraging the greater use of electricity to support industrial development; and

- complex interrelationships of rate structure, financing, patterns of energy use and a different mandate for public utilities.

Although many of the above difficulties might be thought of as transitional, they can have a long duration (for example, 20 to 30 years) and be part of the more comprehensive long-term transformation of energy balances. Considerable disruption can occur if the necessary changes are inadequately handled. Moreover, the next 10 to 20 years are critical to the strategy of backing out oil by increasing the share of electricity in total energy use. Over the longer term, new forms of electricity generation will come from tidal power, co-generation, biomass, solar and low-head hydro. These resources will require different forms of financing, much of which, initially, might take place outside of the provincial utilities. The utilities will be called upon to integrate these sources of electricity into their demand and supply provisions, thus creating greater uncertainty of rates of return to utility capacity. Partly offsetting some of the cost-revenue difficulties is the increasing economic efficiency which the utilities might achieve by selling byproduct heat for district heat, other space heating and low-temperature process heat.

Electric utility financing is expected to account for about one-half of the financial requirements of the principal energy components. Beyond 1990, electricity is expected to provide a larger and a rapidly increasing proportion of Canada's total energy. As a result, utility financing will become an increasingly strategic factor to the achievement of satisfactory energy balances. Because of the long lead times required to install new capacity, and because of the urgent need to solve critical problems of pricing and financing, a greatly increased use of electricity by 1990 is a matter for immediate concern. Attention is now being devoted to the many issues raised, and to the present reduction in rates of increase in electricity demand. However, it is not clear that the much greater long-term reliance on electricity is being taken into account.

An important financial consideration relates to the type of electrical generation which is used. Hydro and nuclear plants gain economies from large-scale installations and from low rates of plant depreciation, but the substantial initial capital costs give rise to high carrying costs for the financing and difficulties in raising funds. The sharply increasing capital costs can be especially burdensome if the growth of demand and, hence,

of revenues falls short of expectations. Oil-fired thermal plants can be added in smaller increments and, hence, can avoid the more extreme problems of high capital costs. However, they are highly vulnerable to rising fuel costs -- potentially an even more serious problem. Using the smaller, oil-fired units would be entirely inappropriate to meet longer term electricity needs. At present, provincial utilities generally favour the high, "front-end", capital cost of large-scale units, hydro, nuclear or coal where it is locally available in large, relatively low-cost deposits. In some instances, (for example, in the Atlantic provinces), increases in efficiency are being sought by regional grids. In other instances, short-term export sales of electricity reduce the burden of high carrying costs for large-scale additions to generating capacity. Longer term approaches to financing can deliberately make greater use of these techniques.

Traditionally, internally generated funds have accounted for about 30 per cent of utility funding; of the external funds, about 70 per cent has been in the form of debt; the balance, as equity. There seems little likelihood that the share provided by internal funds can be increased over the coming 25 years. The higher risk associated with future utility investment suggests that traditional investors might not provide such a high proportion of external financing as in the past. Five courses of action would then be available to utilities:

- raise electricity rates further, thereby generating more internal funds and reducing electricity (and financing) demand;

- seek other ways to reduce the risk to traditional lenders (for example, possibly seek federal government guarantees or form consortia for greater electricity grid participation); or pay higher financing costs for higher-risk borrowing;

- raise a larger proportion of external financing by equity, possibly held in part by large customers;

- receive direct financial assistance from governments; and

- call on funds or financial guarantees which might be available in an energy investment fund, possibly organized as a federal Crown agency but with a broad sourcing of funds.

All of the above considerations (or any combination of them) require innovative approaches to utility financing, to rate structures and to financial management. The first consideration by the provincial utility and the provincial government is to ensure that adequate and appropriate financing is forthcoming to meet the future electrical needs of that province. However, the implications of a number of the relevant financing issues extend beyond the purview of the province and raise matters of national

importance. As a result, the federal government has a direct interest in the outcome of decisions made by individual provincial utilities. Among the broad national interests are the following:

- rate of substitution of electricity for oil in terms of national objectives;
- impact of larger-scale projects on the national economy;
- effect of large-scale financing on Canadian financial markets and on alternative uses of funds;
- impact of large-scale international sourcing of funds on the Canadian balance of payments, the exchange value of the currency and on Canada's international credit worthiness;
- effect on regional policy objectives of differences in electricity rates and of the adequacy of electricity (and energy) supply in various parts of Canada;
- possibility of financial calls on the federal treasury to ensure adequate financing or to provide financial guarantees to provincial utilities;
- opportunities available to the federal government to assist in establishing innovative financial services; and
- opportunities available to the federal government to coordinate provincial utility programs for greater overall effectiveness and to support broader industrial, economic and social objectives in the various regions of Canada.

In summary, the financial requirements for electricity generation emerge, along with the costs and pricing of electricity and financial management, as an important component of the strategic issue area on Financing, Ownership and Control.

Coal and uranium financing

Even though substantial increases in production are expected, no special difficulties are foreseen in the financial intermediation process for coal and uranium mining. Particularly for coal, consortia or customers often play an important part in financing the expansion of mining activities. The participants take a nominal equity position which they then highly lever with debt instruments. Such combined financial arrangements can be expected to increase, but under conditions of greater scrutiny and control. As with natural gas in the 1950s and 1960s, many of the largest customers for coal and uranium are outside Canada, and the financing is tied to the availability of the minerals for export. Hence, long-term export policy for coal and uranium will have an important bearing on the availability of funds and the expansion

of the mining activities unless large-scale customers in Canada (e.g. electric utilities) became involved in financing coal and uranium supplies.

Difficulties in financing coal and uranium mining could arise in other ways. The magnitude of the possible increases in both coal and uranium mining, in total, and the timing of the very large investments, could severely strain the intermediation processes. Remote and costly mine sites will increase unit costs further, and impose additional financing problems. For coal, the conventional thermal and metallurgical requirements will be only part of total demand. Other uses might increase at least as rapidly. These other possible uses include large quantities of coal for use in oil sands and heavy oils operations, the use of western Canadian coal in Ontario, replacement of oil by coal in the Atlantic provinces and of some oil and natural gas by coal in the western provinces. More coal might enter direct use by industry and, finally, the production of SNG and liquid fuels from coal could require substantial financing. In many instances, the nature of the operation, the markets and the risks are not known. The financial intermediation processes, as with other parts of the energy sector, are likely to require innovative approaches and, possibly, government financial participation or guarantees.

Increased environmental and health concerns, control over land use, reclamation provisions and other provincial and federal government intervention will tend to cause delays and add to the uncertainty and to the capital costs of new projects. Changes in tax and royalty provisions create further uncertainties about net returns to operators and the servicing of their financial requirements. Transportation and other infrastructural costs associated with coal and uranium mining are high and can be expected to be relatively higher. Expanded transportation, terminal and port facilities will be required for coal, and community development costs in mining locations also will be high. All of these provisions require additional financing.

Other energy financing

A number of other financial requirements for the energy sector were listed earlier in this section. Among the most substantial of these are: financing conservation and increased efficiency; financing renewable energy resources; and financing RDD&D and technological improvement. Apart from RDD&D, the above activities tend to share some features that will create additional difficulties in the financial intermediation process. Among those features are:

- they are at present unstructured, unorganized activities lacking established corporate and management identity;

- they have no established financial system, record or credit rating;

- they have little or no commercial existence, no assured cost, price, profitability, performance record, or basis for estimating long-term rates of return or discounted cash flows;

- technologies, institutions, constraints, and public acceptance are not known; and

- in some instances, faster write-off of existing capital equipment than originally planned will be called for.

For RDD&D financing, as outlined in Chapter 11, very substantial additional funding is required for a much broader approach to RDD&D activities. These will involve heavier, integrated financial commitments by the federal and provincial governments and industry. The first requirements are entrepreneurial -- initiating, organizing and managing. Among those functions will be the need to establish sources of funds and appropriate financial intermediation services. An exceptional amount of government involvement, both federal and provincial, can be expected for the renewable resources, for conservation measures and for increases in efficiency. It does not follow that governments necessarily will provide either the funds or the intermediation services, but they can greatly facilitate the processes by taking a lead role in organizing the activities with their financial counterparts, and by offsetting some of the risks and uncertainties of the new projects and systems. Entire, new institutional arrangements and regulatory systems will be required and will, in turn, greatly affect the financial attractiveness of this wide range of new, long-term energy projects.

Innovative financing

The above outline has indicated that considerable difficulty will be encountered in future energy financing. The difficulties will spring not just from the greatly "scaled up" magnitude of project financing and of total energy-related financing. New elements of risk and uncertainty also are involved, including a bewildering array of vast projects, incorporating untried technologies, operating in unfamiliar environmental conditions, under inappropriate or, at present, non-existent institutional, administrative and management systems. Many new forms of projects, both large-scale and small, will be competing for funds under novel conditions.

The magnitude of the energy investment projects and the increasing risk of many of them could cause the investment portfolios of financial institutions to become unbalanced unless offsets or guarantees are available from governments or large financial and energy consortia. The timing and scheduling of

projects will do much to determine the ease or difficulty with which financial markets can cope with them. Within the context of a National Energy Program, the priorities established for financing must be consistent with the priorities established in all other parts of the program. Moreover, in terms of access to funds and appropriate timing, the energy projects will compete with all other financial requirements. Two features of the emerging situation merit intensive investigation over the next few years:

- What are the comprehensive, long-run financial requirements of the energy sector, and what timing or scheduling of priorities can be assigned to the many component parts?

- To what extent can existing processes of financing deal, in more or less traditional ways, with the financial needs? To what extent will new sources of funds and financial services be required? How can these be provided?

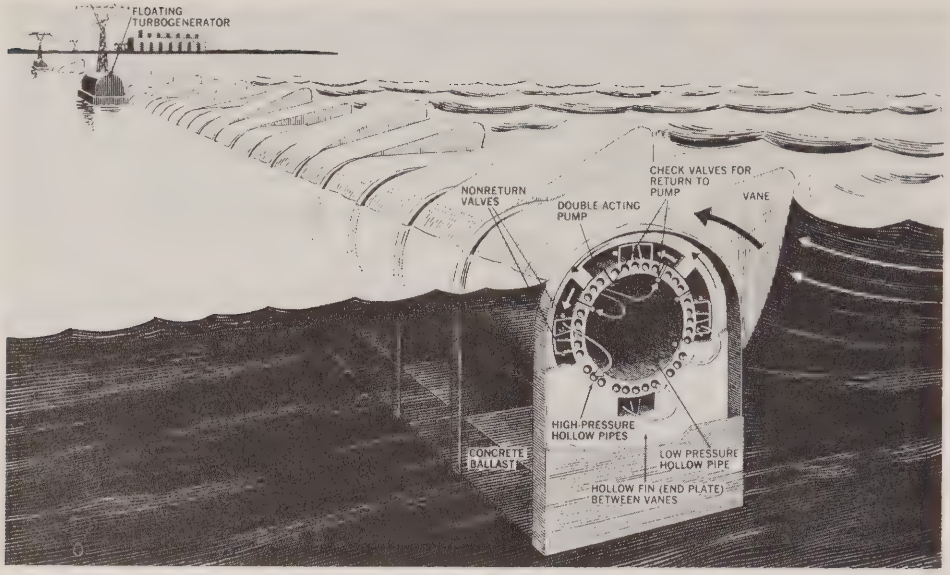
In terms of the sourcing of funds and the provision of financial services, the existing financial institutions and processes, combined with the internal funds of the energy industries, and the existing forms of government funding and guarantees undoubtedly will meet most of the requirements. All of these forms of financing and support are undergoing substantial change, and those changes can be expected to continue. In particular, the role of the federal and provincial governments, acting singly or in concert, is increasing appreciably in energy financing and in setting the conditions within which private financing must operate. The participation of governments will likely increase very much further, in concert with financial intermediaries, the energy industries and others.

Imaginative extensions of existing financial systems and other innovative financial approaches, beyond the increasing role of governments, might include, for example:

- large-scale financing by customers or consortia of customers, mainly equity, for long-term assured supply (possibly buying an equity in reserves in place); these arrangements would represent extensions or new forms of the "take or pay" and guaranteed delivery type of contracts now sometimes used for natural gas and electricity;

- consortia of suppliers and customers, financial institutions, governments and others, including small-scale participants, for a particular energy project or a pool of projects or a sub-system;

- foreign company or government financial participation for long-term assured supply and for financial investment reasons;



Wave and tidal power are possible new energy investments.
(Drawing by Ray Pioch)

- a "revolving investment fund" in which governments, junior energy companies, venture capital and smaller financial institutional investment can come in at early, high-risk stages, then sell the equity or debt interest when operations are well in place, and re-invest in other, start-up projects; the public, small-scale investors can participate either in high-risk, venture equity instruments, or government-guaranteed debt instruments; and

- "revenue bond" type of financing in which borrowing is based on future revenues of projects (possibly with government guarantees) and in which some income tax concessions might be granted to attract Canadian corporate and public investors.

Undoubtedly, many other innovative financial techniques will come forward. The purpose here is to suggest that decision-makers and other financial experts from the energy industries, governments and financial institutions establish task forces and other advisory bodies to assess the aggregate, energy-related financial needs, their timing and priorities and the variety of existing and new techniques which will be required to meet them. These financial activities would be kept under continual review.

Ownership and control

The operation and financing of energy projects cannot be separated from their ownership and control, but there is no necessity for all four factors to reside with the same authority. In the

rapidly changing energy future, the relationships between financing, ownership and control will undergo substantial change. The modifications in the relationship of these factors can do much to determine whether or not satisfactory adjustments are made. In brief, the dominant forms of ownership and control which apply in the energy sector might be described as follows:

- large, integrated multinational companies (principally oil and gas);

- large, Canadian owned or dominated private companies (some oil and gas production, electricity generation, coal and uranium mining; some pipeline transport and natural gas distribution);

- provincial public utilities (electricity generation and distribution; natural gas distribution);

- federal and provincial Crown companies, agencies and joint ventures (Petro-Canada Inc., AOSTRA, Panarctic Oils Limited, AECL, CMHC, Alberta Energy Company, Maritime Energy Corporation); and

- federal and provincial regulatory and control bodies (National Energy Board, Atomic Energy Control Board, Alberta Energy and Resources Conservation Board, provincial utility regulatory and control commissions; departments of resources, financing, transport, environment, and so on).

The evolution of ownership and control in the energy sector in recent years has been toward greater involvement by all levels of government. This trend is expected to continue and to receive increasing support from four groups of factors:

- increasing government control over energy prices, the distribution of revenues and the type and timing of energy investments;

- greater government participation in financing energy projects and sub-systems;

- increasing magnitude and complexity of energy projects, public concern about energy prices, about the size and scale of capital expenditures, and about corporate planning and accountability; and

- Canadian sovereignty and national identity; conservation, environmental and health impacts; land ownership and use and community development; the strategic importance of exports and imports of energy and energy-intensive goods, the world energy and related financial situation.

The much greater share which governments (particularly provincial governments) take of total resource revenues, and their control of revenue size and distribution, make it appropriate that

governments should increasingly be a source of funds or of financial guarantees for energy investments. In addition to tax, royalty and licensing revenues, funds become available to governments as a result of direct government participation, possibly through Crown companies such as Petro-Canada Inc., the Alberta Energy Company, and the Maritime Energy Corporation. Even with the greater involvement of governments, the private financial intermediaries will find a considerable increase in the magnitude of financing they are called upon to provide, and a changing array of conditions of financing, ownership and control within which their initiatives can operate. Greater government ownership, control and participation in energy financing do not of themselves solve the energy problems nor smooth out the adjustment process. Even with government particpation, the basic financial and other economic and social problems remain to be dealt with, compounded by the new ones which the public and governments bring to bear on energy decisions.

Financing, ownership and control, therefore, require a high order of systematic coordination between the energy and financial industries, the federal, provincial and municipal governments, and the public. That coordination will be extremely difficult to achieve and maintain. An outstanding example of coordination has been the development of Canada's nuclear capability from original, pure research to successful deployment on a large scale in Canada and abroad, based almost entirely on Canadian scientific achievement, skills, financing, manpower, equipment and materials. Geological surveys and evaluations under the difficult Canadian conditions rest upon Canadian skills organized within government/industry cooperative efforts. The production of oil from the oil sands and heavy oil deposits, Arctic exploration, the production and transportation of remote resources, and the provision for native cultures offer other examples, now in the formative stages.

The capacity to attract and hold the necessary financing is a fairly simple and objective test of the adequacy of the ownership and control.

In the past, the allocation of a considerable part of Canada's oil, natural gas, coal and uranium production to export markets opened up external sources of funds which have brought with them (except for uranium) substantial measures of foreign ownership and control. However, access to foreign capital, even to equity (ownership) capital, does not automatically require that control be vested abroad. Conditions can be set, as they are in all countries to a greater or less extent, which retain control in Canada. Even for equity capital, conditions may be extremely attractive if, for example, the investment provides an assured, long-term access to scarce energy resources (e.g. Japan's participation in the metallurgical coal industry; past long-term natural gas contracts to United States' customers). This assured supply technique, together with further upgrading and manufacturing in

Canada of energy-intensive products, and marketing of the products through world trading companies offer ways to combine external sources of funds with Canadian ownership, control and financial intermediation. For example, companies (or governments) in the United States, Europe and Japan might be encouraged to assist in the development of in situ oil sand technologies and LNG transport and processing in return for an equity position in the operation, royalties or licensing fees, or a proportion of the production, thus assuring themselves of a future energy supply. Such an approach pre-supposes that the provincial governments and the federal government in Canada have established long-term energy and industrial development strategies and export policies within which the foreign participation can be accommodated.

Uncertainty

"A period of protracted uncertainty produces calls for government leadership and intervention, but there is also a broadly held view that the kinds of structural problems that Canada faces require aggressive initiatives from the private sector."

-INTO THE 1980's; Economic Council of Canada, Fourteenth Annual Review, 1977.

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11. RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT (RDD & D)

Chapter guide

- *The concept of research and development is broadened to deal with the removal of any significant impediment to the achievement of satisfactory energy balances.*

- *Many RDD&D programs will be different in kind because they will have to be keyed on longer term adjustment processes and major transformations of energy systems rather than on individual energy projects. The priorities for technological innovation can best be established in the context of the National Energy Program.*

- *To ensure that successful innovations penetrate as rapidly and as broadly as possible, greater coordination will be necessary of innovative activities by industry, other research centres, governments and on an international basis. The deployment of innovative energy technologies requires concerted attention.*

- *The selling abroad of the "intellectual property" embodied in new Canadian developments can become an increasing activity. These Canadian technologies can be put at the disposal of developing countries.*

- *The new scale of RDD&D activities will require increases in expenditures by the federal and provincial governments and industry.*

- *A principal target is to ensure that RDD&D efforts are systematically directed to overcoming those constraints anywhere in the energy system which stand in the way of achieving satisfactory energy balances or of realizing opportunities for improved deployment of energy resources; RDD&D priorities will then be consistent with other components of the National Energy Program.*

Chapter 11. RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT (RDD & D)

Research and development (R&D) frequently refers to those stages of activity from pure and applied research to the establishment of a proven article or process. For purposes of this report, two additional "Ds" are an essential part of the innovative process. The first of these, demonstration (RD&D), takes the investigation to the point of proving its application. The second, deployment (RDD&D), ensures that a significant commercial penetration of that application is achieved. These four components taken together are referred to in this report as "technological innovation". The process of adaptation must increasingly address the third time dimension -- the future which is 25 to 50 years ahead. As noted in the report of the Technology Task Force for the Long-term Energy Assessment Program (LEAP),

> "We are today being continually reminded of our responsibilities to future generations. One of these responsibilities is to provide, in time, a technical basis for the energy machine they will have to build."[1]

The various new plans and programs noted in Chapter 4 for re-structuring energy demand and the array of new energy supply possibilities noted in Chapter 5 involve a scale of technological innovations which might well be beyond our capacities unless we make the best possible full use of all of the available lead time.

Scope

Virtually all parts of the adjustment process require technological innovations: energy supplies, demand, interfuel substitutions, transportation, new resources, financing, costing, pricing, industrial and corporate structure, organization, management, fiscal policy, federal-provincial relations, regulations and control, energy accounting, information and communication. Innovation, in this assessment, therefore, extends well beyond individual items of equipment, production and delivery processes. Innovation should be directed toward existing and potential opportunities and constraints anywhere in the energy and energy-related systems. The stumbling blocks in the way of making use of many innovations are not in the technologies, but in the economic, social and institutional constraints standing in the way of their implementation. Similarly, full advantage can be

1 See Appendix 3 re assessment task forces.

taken of new opportunities only if an innovative approach is taken to the entire system which will support the realization of the opportunity.

Thus, energy RDD&D encompasses investigations into all aspects of energy, energy systems and the interface of energy, the economy and society. The approach thus moves from pure, or abstract, research right through to financial services and public protests. To get full advantage from this approach to RDD&D requires both a project approach and a comprehensive, program and systems management approach. It requires the integration of energy programs with economic and social programs, and continuous evaluation of projects and systems.

The rapidly increasing use of nuclear power in Canada illustrates a coordinated effort by the scientific community, industry and the federal and provincial governments. Those efforts moved Canada's unique nuclear system through research, development, demonstration and deployment by continuous effort over a time span of more than 30 years. Nuclear power also illustrates another feature of the broad approach. The future growth in nuclear power might not be impeded by technological constraints, but it could be slowed or halted by the concerns, fears and uncertainties transmitted to governments by various groups in society. Important, innovative steps, therefore, are required to determine how best to deal with the hazards and the uncertainties, and how to establish the extent and conditions of public acceptance of nuclear energy. Considerable research and testing are necessary in the laboratories of public acceptance. <u>In the field of nuclear power, Canada is in a position to take world leadership in closing the gap between technical advance and the public's perception of risk</u>.

Nuclear power also illustrates the concept of a broad, energy systems approach. In this assessment, nuclear power has a key part to play in the future achievement of satisfactory energy balances. If public perceptions of risk severely constrain the use of nuclear power, some other energy resource (or disruptive reductions in the use of energy) would be required to meet that need. Alternatively, a different energy supply of the necessary size would be needed which is not readily apparent. Whatever it might be, <u>the costs and risks of the alternative might well be much greater than those associated with nuclear power</u>. The "costs" could include the reduction of economic and social well-being brought about by an inadequate supply of energy.

Priorities

Because we could seriously overtax our capacity to carry out simultaneously all of the innovative efforts, the selection of priorities and the programming of effort through time are

> *"An intense 10-year international program of energy research and development could have the world well along the road to energy abundance by the year 2000. One of many approaches to solving the world's energy problem is through solar power satellites..."*
>
> *-An International Decade of Energy Alternatives: (IDEA), Neil P. Ruzic, The Futurist, Vol. XII, No. 1, February 1978, p. 27.*

essential. These can be established within the priorities of a National Energy Program by industry, research centres and by the federal and provincial governments.

Three strata of evaluation and priority setting are relevant.

These are:

- Projects essential to the National Energy Program -- A "want" list -- what technological innovations will help us achieve sustainable energy self-reliance? (e.g. heavy oil processing, a revised transportation system, a national heating program).

- Projects proposed or recommended by one or more interested parties -- A "wish" list (e.g. coal gasification, electric vehicles).

- Projects which are judged to be feasible undertakings, from a management point of view, at the particular time -- A "work" list (e.g. home insulation, increased furnace efficiency, new forms of nuclear reactors).

A project might be in only one stratum (i.e. be on the want list, the wish list or the work list) or it could be in any two strata, or in all three. The work list typically will establish the most tangible priority, especially if the project is strongly supportive of the national energy programs. However, priorities can also emerge within the want list and the wish list.

Figure 11-1 is intended simply to illustrate an approach to priority evaluation, particularly in terms of government support and participation. Such a technique is only one guide to the

List of proposed projects	Urgent need; short and medium-term benefits	Potential long-term impacts (benefits and others)	LEVERAGE A. Financial (Can a small outlay set in motion much greater financing?)	B. Structural (Will the project unlock a network of activity?)	PROBABILITY OF SUCCESS A. Technological	B. Overcome constraints -resources -prices -environment -institutions etc.	(Less) COSTS A. Total probable cost (and sponsorship)	B. Cost phasing (front-end and committed duration)	C. Non-monetary costs and disadvantages	TOTAL
Examples*										
1. Improved home heating	8	5	5	6	9	7	(6)	(4)	(3)	27
2. Electric commuter carts	3	7	6	6	7	5	(5)	(5)	(3)	21
3. Improved heavy oil recovery and processing	8	9	7	8	8	5	(7)	(6)	(5)	27

* Evaluated on a basis of 10 points maximum - illustrative data only

Figure 11-1. Priority evaluation of RDD&D projects.

general approach to priority evaluation of proposed RDD&D projects. Individual innovators or groups of enterprises might very well be encouraged to proceed with other projects that do not rank high on this scale. The evaluation process can also help to identify gaps in the programs which are being undertaken, and the particular constraints which likely will impede progress. Additional evaluative factors can be included, and more detailed criteria applied for each factor. Considerable uncertainty and subjectivity will inevitably surround such evaluations even when they are carried out thoroughly by highly competent people. One type of uncertainty is particularly important in working toward the application of technological innovation -- scientific risk -- the possibility that innovations elsewhere or in other approaches to the problem will render the project obsolete, or considerably reduce its prospects. Careful monitoring of other activity is essential.

Once some order of priority has been tentatively established, the probability of being able to implement and manage the project, and bring it to a successful conclusion, must be examined. Questions such as the following are to be addressed in order to move a project on to the work list and then proceed with it.

- Who will initiate and coordinate the activity?

- How will the financing be arranged?

- What is the distribution of equity?

- Who owns the intellectual property? -- How is it safeguarded?

- Who will manage the project, and where will it be located?

- What participant groupings are needed?

- Who is responsible for evaluations? (technical, financial, economic, social, the results)

- What are the jurisdictional, legal and institutional implications?

- Who is responsible for linkages, coordination and ensuring that maximum advantage is realized? (e.g. Canadian content, spin-off R&D)

- Who decides second and third order implications and risks?

- What are the international linkages?

The answers to questions such as the above will help to determine whether a project which meets the first test -- a contribution to the recommended actions of the National Energy Program,

and the second test -- establishes a high rating in the priority evaluation -- can be made operational. Can the project be put in place?

Federal government R&D priorities and funding

The federal government's funding of energy research and development for the 1977-78 fiscal year is budgeted at $138 million, an increase of $10 million from the preceding fiscal year. The increases in federal R&D funding in energy is a recognition of some urgency in particular programs. The introduction of new programs, especially in conservation and renewables, is recognition of the beginning of a long-term shift in emphasis.

Aerospace

"Certain experiments, made at the expense of the Aeronautical Society in England, to determine the exact lifting pressure of air currents directed against a plane inclined at different angles, have obtained results that are especially promising."

-Scientific American, 1876.

Six priorities are identified in the federal program:

- conservation;
- liquid and gas fuels;
- coal;
- nuclear energy;
- renewable energy; and
- transportation and transmission.

An interesting feature of these priorities is that they are concerned, in large part, with <u>frontiers</u> of energy systems, the ultimate deployment of which will be many years in the future -- to come at a time when such deployment can contribute to the new energy balances. (By the evaluative criteria of Figure 11-1, they rank high in "potential longer-term impacts".) Details of these programs are provided in the Technology Task Force's Assessment Paper to this "Energy Futures" study. As <u>R&D priorities</u>, the programs are consistent with the transitions identified throughout

this report. Beyond those R&D projects is the need to establish priorities for much more comprehensive RDD&D programs involving all relevant research activities of the community. Within the federal goverment's own R&D efforts, a substantial increase in funding is called for -- possibly from the $138 million for fiscal year 1977-78 to $500 million by 1980-81. A much larger increase could be justified if the expert manpower and the equipment requirements to support a larger program can be found.

Provincial government activities and funding

Provincial government funding of RDD&D activities can be even greater and more specifically directed to local requirements than can the total of federal efforts. For example, the Alberta Government, through AOSTRA (Alberta Oil Sands Technology and Research Authority), has a $130 million research program for Alberta oil sands. This program, which the Alberta Government agency funds and coordinates, advises on the allocation of activities by private companies, and holds the resulting intellectual property. AOSTRA is a particularly imaginative approach to the management of intellectual property and for committing significant research funds to provide leverage for more effectively directing other funds. Other provincial governments have programs in operation to serve similar objectives within the context of their provincial priorities.

It might be well to note here also the much more ambitious approach being taken by the United States Government to meet the urgent requirements of technological innovation for energy. Under the general coordination of the Energy Research and Development Agency (ERDA), federally funded energy R&D programs quadrupled from an annual budget of $500 million in the early 1970s to over $2 billion in 1976. In 1977, ERDA sponsored a Market Oriented Program and Planning Study (MOPPS), the purpose

Jet propulsion?

"It is possible that the principle of jet propulsion can be applied to the airplane?... American investigations on the subject have put in doubt the possibility of obtaining any great efficiencies, but for exceedingly high-speed planes and simplicity of the apparatus and the elimination of the propeller lead us to think that further developments are worth watching."

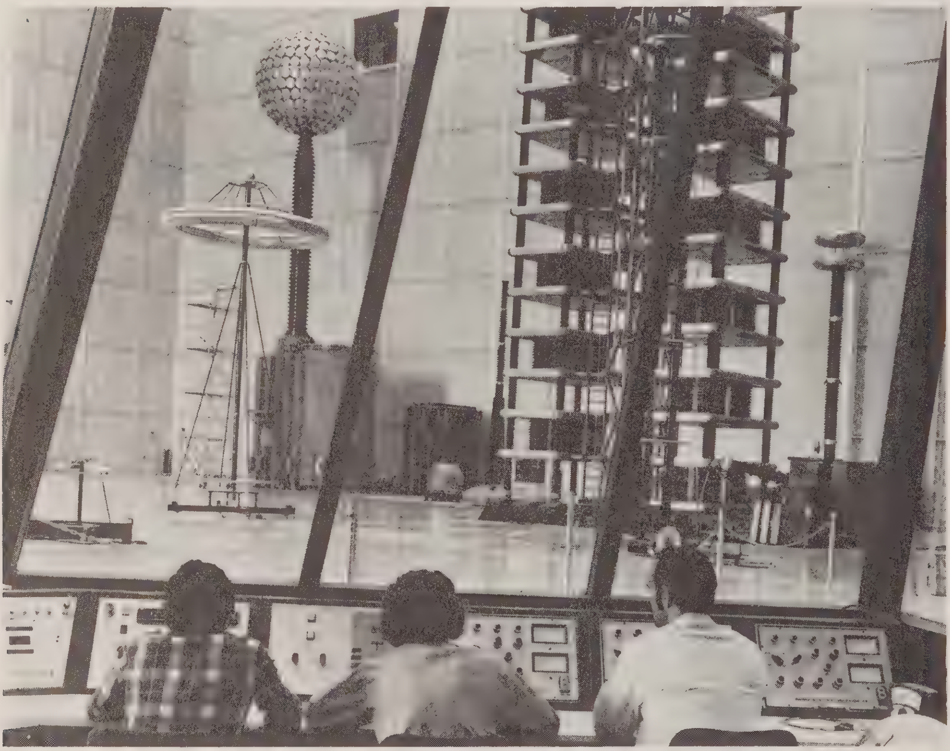
-Scientific American, April 1926.

of which was to ensure an extensive interface of government experts with the energy industries in an attempt to identify how various arrays of market prices for oil might call forth alternative sources of energy, and in what amounts.

RDD&D programs in total

Although very large sums of money go to energy research from business and from the federal and provincial governments, the broad "systems and interface" approach to technological innovation, here recommended, would require that those funds be substantially increased, and that the priorities and programs be coordinated to achieve satisfactory energy balances over the long term. The federal government undoubtedly must have a major initiating, supporting and coordinating role in the much expanded RDD&D efforts, but initiatives should be as widespread as possible among innovative centres. Five main action centres for technological innovation include:

- industry;
- federal government projects;



Energy research, tests and demonstration will take many new forms, and increase substantially in cost.
(Photo: J.-R. Hamelin, IREQ)

- provincial government projects;

- educational institutions, private research centres and individuals; and

- other countries.

Maximum advantage from technological innovation will be achieved when the efforts of those five sources are coordinated. For some projects -- for example, fusion power, SNG and LNG production and transport -- most of the research and development probably will occur in other countries. If Canada is to reap early benefit from those efforts, it must be an active participant and contributor to the international effort. Beyond international participation, the scope for uniquely Canadian contributions to technological innovations is great. Those contributions can cover a wide spectrum of energy and energy-related projects and programs. An important objective of technological innovation is to establish a Canadian leadership position which will permit the sale abroad of Canadian high-technology services and equipment. That expertise applies to individual projects such as the CANDU reactor, oil sands technology and, possibly, biomass and tidal and wave projects. However, the expertise can also extend through the much more comprehensive scope of RDD&D which is postulated in this report, to include, for example, energy financing approaches, institutional re-organization, manpower policies, the incorporation of public participation, the interface of energy innovations with industrial, economic and community development, environmental and land-use innovations, and energy management systems within national energy programs. Marketable services can be developed over a very wide range of energy-related activities. These complex extensions of RDD&D activities, their coordination within agreed upon priorities consitute a strategic issues area for concerted follow-up activities. Thus, the challenge in respect of technological innovation is among the most crucial in determining whether or not satisfactory energy balances can be achieved and sustained over the long term.

The auto age

"The Brayton gas engine...has been made the basis of another invention of somewhat similar nature, in which the motive power is furnished by burning a mixture of crude petroleum vapor and air. The oil engine bids fair to be a successful machine, and one of considerable utility to those who require light power but who wish to avoid the inconvenience of steam."

-Scientific American, December 1875.

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12 OTHER ADJUSTMENT FACTORS

Chapter guide

- *Manpower, equipment, materials and infrastructural requirements for the energy and energy-related sectors will increase in amount and in diversity beyond anything experienced in the past, and will require longer advance preparation.*

- *Environmental, health, land and water use, and other social considerations require a much more comprehensive and systematic approach in relation to the evolving energy projects. In this context, energy developments can be regarded as part of environmental and land-use considerations rather than the other way around.*

- *Existing institutions, regulations, administration and management systems require extensive modification in objectives and procedures to support satisfactory energy balances.*

- *Full public participation in the major transitional processes can only be achieved if a clear reference framework exists within which the public can assess the energy objectives, the plans and programs and its participation.*

- *These adjustment factors are brought together in ways which are mutually supportive of satisfactory, sustainable self-reliance in energy over the long term.*

Chapter 12. OTHER ADJUSTMENT FACTORS

This chapter touches on factors other than those of chapters 8, 9, 10 and 11, which will be instrumental in determining whether the necessary, massive adjustment process can be successfully carried out over the coming 25 years. Each of these factors constitutes a strategic issue area within the National Energy Program. The priorities and programs for each factor separately have to be consistent with those of the other factors if they are to be mutually supportive of the National Energy Program.

The factors outlined in this chapter are:

- manpower, equipment, materials and infrastructural requirements;

- environment, health, land and water, other social considerations;

- institutions, regulations, administration and management; and

- information, communication and participation.

Manpower, equipment, materials and infrastructural requirements

Among the most serious constraints to satisfactory energy adjustments might well be an inadequate supply of manpower (particularly certain skills) and of types of capital equipment and materials. In addition, infrastructural requirements (roads, railroads, ports, utilities, community services and housing in new energy centres) will be called upon to keep pace with a host of energy developments, often in remote areas. To provide the requisite manpower will require an extensive and systematic approach to training facilities, labour union participation, provisions for labour mobility (including temporary settlements and provision for commuting to remote sites), and provision for labour stability (community and recreational services, job opportunities for women). Although the assessment of requirements should be as comprehensive as possible, an important characteristic of meeting the needs will be variety and flexibility in approach from one location to another, and from one type of energy project to another.

In some respects, supplying a work force to the energy system is analagous to supplying the capital. In a situation of fairly full employment, especially for skilled workers, the energy sector will compete for manpower against the demands of other

sectors. It often will be called upon to develop its own skilled labour force, competitive working conditions and living amenities. These labour force considerations and their financial counterpart require management action within the total energy complex just as much as does the exploration of geological formations. They also require the full support of labour unions and of manpower training and placement centres.

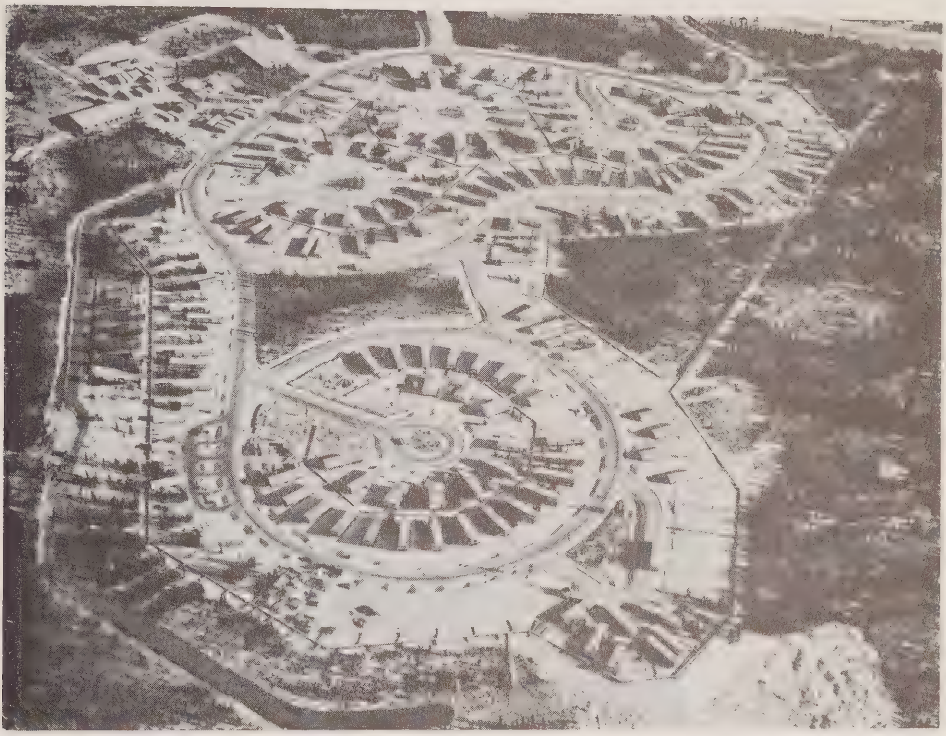
The supply of materials and capital equipment to the energy sector is another major area for investigation. This includes not just the production capabilities which do exist, but even more particularly those which do not. Careful, systematic assessment is needed of the total supply requirements of new energy projects, new systems, and support industry expansions. For example, what are the equipment and material requirements of 10 heavy oil and oil sands plants, together with their coal, transportation, processing, environmental, land reclamation, repair and maintenance systems, and of the steel mills, etc., to supply them? Or, of two or three frontier pipelines? Or draglines for expanded earth-moving projects? To what extent are Canadian industries gearing up to supply those needs? What are the capital investment requirements of these support industries?

In large part, the constraints and bottlenecks which might develop in these support industries can be avoided. If the constraints occur, they could threaten the future energy balance. Avoiding the constraints offers new employment opportunities and scope for dynamic, innovative management. If the long-term energy objectives and programs are generally accepted (with whatever modifications) industry, the financial institutions, labour unions and training schools can gear up to ensure that manpower, materials and equipment supplies are forthcoming when and where they are needed. The objective should be to ensure the greatest possible supply from Canadian productive resources, organized in efficient, competitive ways. <u>The manpower, equipment, materials and infrastructure requirements of the energy sector can become the core of improved employment and dynamic industrial opportunities in all regions of Canada</u>.

Environment, health, land and water use and other social considerations

Environmental protection illustrates a worldwide concern for mankind's impact on the world in which he lives. The realization is growing that our activities can so pollute the environment and so alter the biospherical balances that survival of life on earth is threatened. Activities are increasing which are designed to arrest further deterioration of the environment and to rehabilitate badly affected areas to more acceptable life-support conditions. The management of land and water resources encompasses closely related concerns.

In this "Energy Futures" assessment, environmental concerns stand proxy for the broader range of social and health concerns, all of which merit more detailed investigation within a strategic issues area study.



Remote communities and greater land-use are among the many social concerns over diverse energy developments.
(Photo: Alain Rinfret, Hydro-Québec)

Three characteristics typify many of the newer environmental concerns:

- The scale of operation requires a comprehensive, advance assessment -- one additional coal or oil sands surface mine, or one more nuclear plant might have only a small environmental impact, but what of 20 in the same general area?

- Very little is known about the environmental impacts of many of the evolving energy projects (LNG, Arctic drilling, biomass, large numbers of oil sands or nuclear plants).

- Public awareness, concern and protest often centre on the new kind of energy projects at least in part because the environmental and public safety aspects are so little known that the risks appear to be larger than for existing systems. Full, comparative criteria and assessments are required.

Energy and environmental assessments constitute an interlocking of two fundamental support systems for human existence and advancement. Long-term energy programs require that full and systematic assessments of environmental impacts be made as part of the advance planning process, not just for individual energy projects but also in terms of the impact of entire energy systems. At the same time, environmental protection measures will be called upon to accommodate essential energy-support systems which are essential for society, and do so without unnecessary delays. Environmental standards are required which are definite enough to maintain environmental protection, but flexible enough to meet different energy situations. Modifications of both energy and environmental programs will be necessary to find mutually satisfactory combinations. Advance preparation of environmental standards should, therefore, go hand in hand with the long-term energy programs. Trade-offs are necessary between an absolutely inviolate natural environment and the economic and social needs and aspirations of people -- in terms of local populations and the provincial, regional, national, international and global communities. The public concept about these trade-offs is usually imprecise and uncertain in part because the information is, often of necessity, also imprecise and uncertain. The public and the project designers, managers and approving authorities are required to form some balance, consciously or unconsciously, of short, medium and long-term costs and benefits. Long-term developments will require that more be done to assist all parties to make reasonable appraisals and to act responsibly in the public interest. Considerable progress has been made in recent years to achieve that objective on an individual project basis. Much more remains to be done, particularly in terms of combinations of large-scale energy systems. Three, large environmental studies include the continuing Great Lakes environmental studies, the en-

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Oil spills

"The time has come to put an end to the abominable nuisance caused by oil-burning ships discharging residue from their tanks on the high seas and within the harbors and ports of the world. This filthy mess is defiling many of the most attractive bathing resorts; it is endangering the shipping in our harbors because of the liability of the floating oil catching fire, and it is causing widespread destruction of the bird life of the seas."

-Scientific American, August 1925.

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vironmental and community impact studies for the James Bay hydro projects, and the environmental assessments and local community impact studies associated with northern oil and gas exploration and pipelines. Such studies, and a host of smaller ones, are only a sign of what is required.

Environmental protection programs are costly, both in terms of direct costs and in terms of delays and modifications introduced into energy programs. Estimates vary considerably as to cost, but possibly 10 per cent of capital cost might go to the direct environmental safeguards. On the estimated capital projects for energy to 1990, amounting to $180 billion (1975$), or more, environmental costs, therefore, might be $18 billion -- possibly $1.5 billion a year. That estimate might be much too low. Spread over all projects, environmental protection, effectively planned and implemented, need not add greatly to the cost of energy or to the price of the final goods and services in which the energy is embodied. A matter of concern, however, is whether environmental and similar social costs impact different projects and systems inequitably simply because of differences in our knowledge, our concerns, or because of jurisdictional and institutional differences that have little to do with the comparative environmental impacts of the various projects. At a time when substantial changes will be required in the mix of energy supplies and uses, it is important that the establishment of environmental standards and procedures support, as far as is practical, the required energy transformations.

Questions remain of how the capital costs are to be financed. Typically, the capital cost will be assigned to the final product and incorporated into its price. On occasion, because of some broader social benefit, or because of particularly demanding environmental requirements, part of the cost might be borne by government or by others.

Environmental assessments should be conducted by objective evaluators, possibly in an independent agency that conducts reference environmental assessments of areas and projects in advance of the undertaking of projects (energy or other). The environmental assessments would be public information. To some extent, this activity is encompassed in the federal Department of the Environment and in various provincial bodies (e.g. the Alberta Energy Resources Conservation Board). There is scope for a substantial enlargement of those activities.

The same approach is required for environmental considerations as for all other aspects of energy assessments -- namely, the adoption of an integrated, energy systems approach in which priorities are consistent within the National Energy Program. The environmental requirements, for example, for nuclear power generation and electrical transmission from nuclear sites to

markets should be treated as an environmental entity so that the full environmental impacts and costs of preventive and remedial actions can be assessed in total. These can then be compared with, say, the environmental impacts of mining, transporting and using coal to provide the same quantity of electricity to that same market.

The absence of adequate mechanisms to establish and to incorporate quickly environmental protection measures and to deal with public concerns can cause uncertainty and delays in setting energy priorities and carrying them forward. Three principal requirements therefore emerge:

- Full weight must be given to public concerns (environmental and other) and the participation of special interest groups, particularly expert groups, in the decisions and implementation of long-term energy projects.

- Advance time and assistance should be provided to ensure that public participation is effectively and responsibly made.

- Rules of procedure, criteria for decision-making and evaluative processes should clearly established so that "rules of the game" are known so that participants can make definite contributions. Decisions can then be made and programs implemented with minimum delays once the public concerns have been fully assessed.

Institutions, regulations, administration and management provisions

A major transformation of the energy system calls for an equally great change in the institutions (both public and private), and the regulatory, administrative and management systems by which energy is supplied and used. Revisions of these institutional and management facilities will need to be considered in a functional sense, in terms of the long-term objectives and targets.

- What are we trying to accomplish?

- What is wrong with how we are trying to do it?

- What explicit changes are required?

- Who has (or should have) responsibility for the projects and the changes?

- When and how can the changes be brought about?

- What might be their other impacts?

Substantial institutional, regulatory and management changes already are underway -- for example, in energy conservation (home insulation programs, building and insulating guidelines, automobile performance requirements, speed limits, information programs); in federal and provincial fiscal incentives to petroleum exploration; in uranium and coal policies; in the Maritime Energy Corporation, and in many other examples. The activities of other institutions and regulatory procedures have been greatly expanded to deal with the much enlarged energy activities and new types of programs which were not clearly foreseen when the institution and regulatory provisions were first introduced. The large-scale, national impact studies now being undertaken by the National Energy Board are examples of a large-scale evolution of activity. Revision to the duties of the Atomic Energy Control Board and changing building regulations by the Central Mortgage and Housing Corporation demonstrate both the importance and the difficulty of designing and operating institutions, regulations and administrative systems to deal with rapidly changing and expanding energy events. The task of ensuring that institutions, regulations and management systems will effectively serve the long-term future is even more difficult. A clear perception of objectives and targets will help the process of continually revising these support and control activities.

In terms of the long-term energy assessment, the initiatives will need much broadening to provide, for example, for the systematic deployment of renewable resources; re-structuring industrial and municipal use of energy; revising, in a comprehensive way, pricing and financing provisions; initiating manpower, materials, equipment and infrastructural support; for a systematic and greatly expanded approach to technological innovation and environmental concerns; for public participation; for integrating the activities of federal, provincial and municipal governments with those of a number of supplier, user and support industries, special interest groups, and so on. In short, the institutions, regulations, administrative and management procedures for each component of the energy system and for the system as a whole require comprehensive and coordinated assessment. <u>The objective is to test the apparent adequacy of institutions and procedures, to identify the necessary revisions and extensions if all of the indicative targets for satisfactory energy balances are to be achieved</u>. The magnitude of the task of review and revision of institutions, regulations, administrative and management procedures becomes a <u>strategic issue area</u> for intensive investigation.

Many difficulties in carrying through energy programs result from the constitutional division of powers. For purposes of this assessment, no constitutional or jurisdictional changes are assumed or recommended. The approach here is to seek intensification of efforts to reach agreement and work out coordinated approaches to specific priorities and programs such as those required, for example, for the proposed national heating program, consolidated energy supply program, the transportation and indust-

rial energy programs, and the economic and social opportunities program.

Satisfactory energy balances for the long-term future will be delivered by centres of leadership and initiative across the country. These will be found in industry, municipalities, labour groups, centres of learning, the provincial and federal governments. The more centres of leadership the better, provided they are not working at cross purposes. The federal government has a particularly important role in the initiation and coordination of policies and action for that energy future, and for the economic and social futures so dependent on it. Within that context, institutions, regulations, administrative and management procedures can form either constraints or opportunities for the achievement of a successful energy future. Cohesion of purpose and of action will be extremely difficult to achieve. It will be aided by shared assumptions and common objectives. The contrast between what might be achieved for Canada through the implementation of well conceived, long-term programs and what might result without them is a vivid backdrop against which to seek agreement.

For the most part, institutions which are now in place, if revised and extended, are probably adequate to deliver satisfactory energy balances. We should be reluctant to assume that new institutions are required everytime that a new problem arises. New ways of using existing institutions and of coordinating their efforts might be more productive. Many new services will have to be provided, often by bringing institutions together in new combinations. At the same time, assessments are required to ensure that any casual or ad hoc extension of the activities of an existing institution is the appropriate way to deal with a new situation.

"But the fact remains that on energy legislation we have failed the American people. Almost five years after the oil embargo dramatized the problem, we still do not have a national energy program. Not much longer can we tolerate this stalemate. It undermines our national interest both at home and abroad. We must succeed, and I believe we will."

-President Carter's State of the Union Address as prepared for delivery to a Joint Session of the Congress January 19, 1978.

The principal components of the adjustment process through institutional, regulatory and administrative change are illustrated in Figure 12-1. Two important features emerge:

- initiatives for new approaches can be taken by all of the interested parties; and

- coordination of the widespread, diverse initiatives is essential.

Energy information, communications and participation program

The necessary transitions in all of the above activities will be most readily achieved as a result of widespread discussion and participation. Task forces and industry and public working groups can help to carry out that participation. Effective action will require comprehensive, well integrated energy information systems. These will support government policies, industry initiatives and the fullest possible public understanding and response. Thus, essential to the success of a National Energy Program is a fully developed support system of analysis, energy accounts, energy budgets and reports, broadly communicated throughout the country in ways which identify local interests as well as national, systematically using inputs from participants in all parts of Canada. It would demonstrate, for interested parties and the public, the relevance of current initiatives and of public response to those initiatives within the context of the long-term assessment. It would also assist to monitor, evaluate and revise the national energy targets, programs and national energy accounts. The national energy information system would show the relevance of updated information on international and global energy events -- <u>a world energy watch</u>. The establishment of these programs with widespread participation is another <u>Strategic Issue Area</u> identified in this assessment and is included in the recommended programs of Chapter 13.

"...perhaps future historians will point to the failure of our nation to respond to the warnings of an energy crisis as an example of the obsolescence of the democratic form of government in a modern world with limited resources."

-V. Kikuchi and J.J. Duderstadt, Professors of Engineering, University of Michigan, New York Times Letter, October 4, 1977.

I. THE PRINCIPAL COMPONENTS

(A) GOVERNMENTS

- ASSESSMENT OF NEED
- CONSTITUTIONAL FRAMEWORK
- CONSULTATION
- FEDERAL-PROVINCIAL AGREEMENTS
- LEGISLATION
- REGULATION
- IMPLEMENTATION & ADMINISTRATION
- RESPONSE
- EVALUATION
- REVISION

(B) INDUSTRY AND OTHERS

- ASSESSMENT OF NEED
- MARSHALLING A CAPABILITY TO INITIATE CHANGE
- IMPLEMENTATION
- RESPONSE
- EVALUATION
- REVISION

(C) PARTICIPATION IN, AND RESPONSE TO INTERNATIONAL INITIATIVES

II. THE PRINCIPAL INITIATORS AND COORDINATION

INITIATORS	COORDINATION
A FEDERAL OR PROVINCIAL DEPARTMENT	INTERDEPARTMENTAL COORDINATION FEDERAL/PROVINCIAL AND INTERPROVINCIAL COORDINATION
AN INDUSTRY	INDUSTRY/GOVERNMENT/PUBLIC COORDINATION *
AN INTEREST GROUP; FOREIGN COUNTRY OR INTERNATIONAL	GROUP/PUBLIC/GOVERNMENT/ INDUSTRY/INTERNATIONAL COORDINATION

* The multi-party coordination applies generally throughout the earlier stages as well.

Figure 12-1. Adjustment process and initiation of change.

The principal objectives of such an information and participation program are:

- help to coordinate federal-provincial-industry initiatives and programs;

- support an additional range of national, regional and local programs designed to deal consistently with the long-term energy transformations which will be necessary to provide Canadians with a satisfactory economic and social future;

- identify the programs with highest priority and undertake immediate consultation and action on them while, at the same time, establishing a capability to coordinate systematically the other energy-related initiatives across Canada;

- call upon provincial and local governments, various industries, labour organizations, special and local interest groups, and the public to support the overall perceptions, the targets, the specific programs and the tentative programming, or to recommend alternatives which might better serve their interests and the national interest;

- ensure that the public continually understands the gravity of the energy situation, the implications of changing developments, and that members of the public realize that their participation is essential to a solution of the difficulties; and

- help to ensure that the necessary structural changes, manpower, materials, equipment and infrastructure programs are brought about as needed for the effective application of changing energy programs.

Among the principal components of the information, communications and participation program are:

- A set of indicative <u>energy targets</u> (national, regional and provincial) would show what is to be achieved through various time periods; how it is to be achieved, and what the relationship is of particular targets to satisfactory, overall energy balances. Provision for widespread discussion would be made, and provision for target revisions.

- <u>National (and provincial and regional) energy budgets</u> would be drawn up, showing changes in supply, demand and associated factors, as they exist and as they might change over various future time periods. These energy budgets would support <u>energy reports to the nation</u> on progress toward sustainable energy self-reliance, changing circumstances, program revisions, and so on. The purpose would be to maintain a dynamic frame of reference for discussion of energy priorities and for coordination of plans and programs across the country.

- A set of national energy accounts, analagous in many ways to the national income and expenditure accounts of the gross national product, with regional and provincial detail, would be provided. In addition to the detailed system of accounts, concise summary accounts would enable widespread public appreciation of the principal developments. These accounts would be economic as well as physical (i.e. would contain value, cost and price information).

- Analytical models would underwrite the accounts, permit linking of related models within Canada and abroad to ensure that all major components of a comprehensive energy system were included, and that their linkages through the system were articulate.

- Energy/economic/social accounts. The principal inter-relationships of energy developments to the economy and to society would be identified and assessed. These would include, for example, fiscal, monetary and balance of payments relationships; energy financing and pricing; manpower, equipment, materials and infrastructural support requirements; the principal energy-using industries; the associated industrial, community and regional implications associated thereto; environmental health and conservation considerations; public response.

- Energy-related international relations would contain comprehensive assessments of future world energy balances, relevant population, economic and social information and multinational corporate relations (a world energy watch); Canada's international trade in energy and energy intensive products; international financing, balance of payments implications; multinational and bilateral arrangements; cooperation with developing countries; participation in international institutions, agencies and research projects. The international assessments would be made in ways which would permit integration with national and provincial energy programs with a view to ensuring that maximum advantage can be taken of Canada's comparative, potential strength in energy.

- All components of the analytical program would be used, in conjunction with other information, as the basis for widespread information and communications programs. Two essential features of an assessment program are:

  (a) the comprehensive and systematic assembly of energy-related information into an interactive framework; and

  (b) the establishment of a communications network in which interested Canadians can participate both as users and suppliers of information in which they can appreciate the relevance of their interests and concerns.

Several characteristics of the programs help to illustrate those features:

- The energy information and communications programs would be designed as an information utility to reach as many people as possible at the appropriate levels of information and discussion -- from experts in some phase of energy supply or technology to financial experts, environmental groups, principal energy users, and members of the general public.

- The information and communications programs would emphasize inputs from provincial and local levels which, as appropriate, would be assembled into larger aggregates up to national and international levels. The provincial and local information would also be assessed in relation to national objectives, targets, priorities and programs.

- A coordinating centre (or secretariat) would provide general support services.

- The information and communication programs would be two-way or multi-way flows, with responses elicited and the responses assembled and transmitted back to relevant interests.

- The information and communication programs would provide for the systematic incorporation of the assembled information into related bodies of information so that energy impacts can be continuously assessed.

- A full range of media forms and communications techniques would be used. The techniques would include, for example, task force, ad hoc special committees, workshops, seminars, conferences, exchanges of reports and comment, public and special-interest meetings, as well as media programs.

The above brief outline indicates that the analytical, information and communications programs are designed to underpin long-term energy transformations to try to ensure satisfactory energy support to the future economic and social well-being of Canadians. The programs provide a common, long-term reference base for governments, industry and other participants as an aid in the decision-making process. The programs are designed to assist participants in all parts of the country to assess the relevance of their energy-related activities to the national energy purpose. The programs should point up consistencies and inconsistencies in the perceptions and the activities of participants, thereby helping to pinpoint critical areas for re-evaluating, revision, new initiatives and additional effort.

Process of adjustment, summary

Chapters 8 to 12 have dealt with many of the factors which must be harmoniously brought together if satisfactory adjustments are to be made. Principal among those factors are:

- prices and pricing policies;
- finance, ownership and control;
- technological innovation (RDD&D);
- manpower, equipment, materials and infrastructure;
- environment, health, land-use and other social considerations;
- jurisdictions, institutions, regulations, administration and management; and
- information programs and public participation.

Recommended programs are given in Chapter 13 for each of those factors, but it is essential to recognize that the individual factors must be drawn together into mutual support for long-term energy objectives. These, in turn, are called upon to support more basic economic and social objectives. The integration of these diverse activities will be taking place at a time of great uncertainty, under rapidly changing conditions in which substantial, longer-term transitions will be underway and facing very difficult conditions. The long-term transformations require consistent actions throughout especially long lead times. A great deal of discussion is in order simply to assess how different the approaches themselves must be from those which we have been accustomed to use. There seems no way to achieve a comprehensive, systematic, integration of so wide a range of activities, under difficult and rapidly changing conditions, to serve long-term objectives, except by a continuous, widespread process of "concertation". That requires bringing together the perceptions, interests and priorities of people all across the country into discussions of and agreements on a National Energy Program.

"In the end, not only have the procedures of public enquiry and review been non-harmful; they have also been positively beneficial."

-S.R. Blair, President and Chief Executive Officer of the Alberta Gas Trunk Line Company Limited and Foothills Pipe Lines (Yukon) Ltd.

Part IV

CONCLUSIONS AND RECOMMENDATIONS

Chapter 13. NATIONAL ENERGY PROGRAM — RECOMMENDATIONS

NATIONAL ENERGY PROGRAM

Situation and necessity

This assessment concludes that the world energy situation could well enter an extremely critical phase within the next 10 or 15 years -- so critical that the well-being of people in many countries might be seriously damaged and world order itself threatened. The deteriorating world energy situation will show up in the form of higher prices and might well cause serious disruptions to energy supply. The difficulties will be evident first in the world supply of oil. Even if this "Futures" assessment has overestimated the magnitude or speed of the deterioration, the basic direction of movement remains. At best, we would have a few more years to make the major transformations that are required.

The preceding chapters have outlined how new energy balances might be achieved in Canada over the next 25 years. They have dealt with the need for substantial institutional changes and for a clear, systematic approach to other factors of adjustment -- prices, financing, technological innovation, environmental concerns, land-use, etc. The report takes as a starting point the objective of enhancing economic and social well-being and of ensuring that an appropriate energy system will always be in place to support that objective.

A National Energy Program would pull together all the diverse activities, and do so in a dymanic, flexible way, supported by Canadians in all parts of the country. The National Energy Program would use long-term, indicative targets and interim performance targets to permit assessment of need and of progress. A coordinated program, with full public participation, is essential for a successful energy transformation. The program would represent a change in perception as well as in approach. Sectoral programs (such as nuclear power, an array of oil sands and heavy oil plants, a bank of renewable resource projects, a national heating program, transformed, industrial and transportation systems, and re-designed communities) incorporate a great array of individual energy projects -- for example, the next nuclear plant, the next oil sands operation or home insulation programs. Those on-going, short-term projects would be timed, as far as possible, to support the long-term, comprehensive programs and objectives. Within this comprehensive and integrated approach can be fitted the many important initiatives already being taken, for example, by the federal government in implementing the interim objectives of the strategy report.

The success of the energy transition to the year 2000, and from then until 2025, will not be determined by whether we build one or two more oil sands plants, or nuclear power stations or pipelines, or whether we learn to use more effectively forest slashings or city garbage as fuel. Success also will not be determined by whether we insulate one-quarter of our houses, or increase automobile performance to 40 miles per gallon of gasoline -- important though all of these achievements are. Satisfactory energy balances will exist beyond 1990 if we begin now to do all those things and very many more besides within an integrated approach to meet commonly held objectives. The greatest stumbling block to a satisfactory energy future will not be a shortage of energy resources in Canada, nor will the deterrent ultimately be the "high cost" of Canadian resources. Before the end of the century, Canadian energy resources will not be high-cost by world standards. Success will hinge on how well and how quickly we can mount the effort, the skills and the ingenuity over a vast range of activities -- how well we can manage our affairs, develop our institutions, dedicate the effort locally and nationally. Taken all together, the tasks will certainly be the greatest in magnitude and complexity undertaken by Canadians in peace time. Very real advantages will accrue to all parts of Canada from strong, nationwide energy links.

Framework of recommendations

The framework within which the recommendations are organized is illustrated in Figure 13-1.

Policy elements and indicative targets

A number of policy elements support the objective of the National Energy Program to achieve sustainable self-reliance in energy by 2000, and then to maintain it. The policy elements give rise to indicative targets which can help to organize and coordinate programs, establish the need for revisions, and evaluate progress and results. The policy elements and the indicative targets are supported by sets of programs. Shorter-term performance targets provide, in a dynamic way, for evaluation of progress. The specific objectives for each program are supported by recommended actions. Taken together, the policy elements, targets and recommended programs move us toward a National Energy Program.

Policy elements

Five main policy elements are set down, each of which gives rise to sets of programs. The five policy elements were illustrated in Figure 13-1. They are:

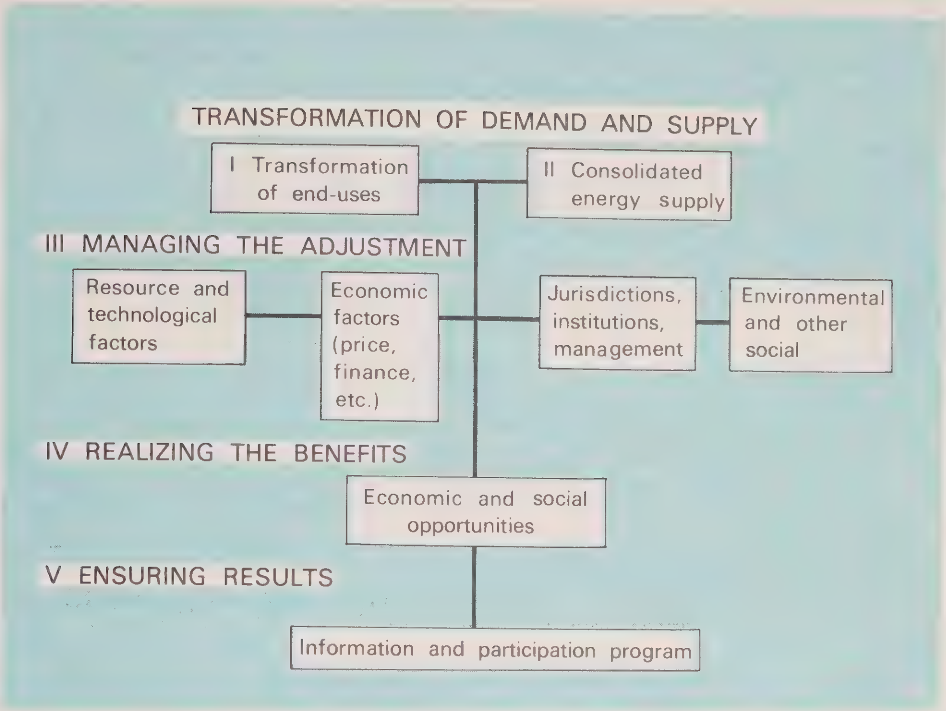

Figure 13-1. Achieving new energy balances for sustainable self-reliance.

- **Transformation of end-uses.** Transform energy end-uses to conform to the energy we will be able to have from Canadian sources. (five recommended programs)

- **Consolidated energy supply.** Establish and maintain, in a flexible, dynamic way, an appropriate mix of indigenous energy supplies for Canada and for each province and region. (eight recommended programs)

- **Facilitate the adjustment process.** Ensure that factors of adjustment (such as prices, financing, ownership, environment, innovation), individually and collectively, support the energy transformations which are necessary to achieve and maintain satisfactory energy balances. (seven recommended programs)

- **Realize economic and social opportunities.** Achieve the economic and social benefits inherent in bringing about the energy transformations and in using the transformed energy systems. (four recommended programs)

- **Information and public participation.** Establish comprehensive information and communication programs to coordinate energy-related activities across Canada and to achieve widespread public support. (four recommended programs)

Indicative targets

Supportive of the above policy elements are a number of indicative targets. These, in turn, would incorporate interim performance targets designed to establish the flight paths for action. Continuous reassessment will be required of the evolving energy situation in order to revise targets and programs.

The principal indicative targets are:

- Reduce the growth rate in energy demand for the period 1978 to 2000 to one-half the 5.3 per cent historic rate; cut the growth rate in energy demand in half again for the years 2000 to 2025. This requires not just further conservation and increased efficiency in current patterns of use, but radically altered patterns of use and supply of energy in ways which support satisfactory economic performances and enhanced personal and social well-being.

- Reduce the share of oil from 46 per cent of primary energy to 30 per cent by 2000 and to 25 per cent by 2025, and reduce the share of imported oil to not more than 10 to 15 per cent of that lower oil share (not more than 400 000 barrels a day by the year 2000); reduce oil imports to negligible amounts by 2025.

- Increase Canadian oil production by about 50 per cent by 2000 and sustain that level to 2025 -- principally from oil sands and heavy oils (with any frontier or other new discoveries worked in); this would require possibly 15 oil sands and heavy oil plants by 2000, staging one new plant every 18 months -- an extremely difficult task.

- Increase natural gas production by at least one-third by 2000 and sustain that production or increase it further to 2025 -- permitting a new gas wedge, based on an assured supply, to be driven into the markets of central and eastern Canada.

- Increase coal production four or five times by 2000, with further substantial increases to 2025; extend the use of coal to many new applications.

- Increase by one-half the share of electricity in total primary energy supply so that electricity is providing at least one-half of total primary energy compared with about one-third at present. This will require increased hydro, coal and nuclear generation, as well as some combination of co-generation, use of tidal, low-head hydro and other renewables and byproduct energy.

- By 2000, supply at least 5 per cent of primary energy from renewables (other than conventional hydro) and 10 per cent by 2025. Those amounts are the equivalent of about 400 000 barrels of oil per day in 2000, and one million barrels per day by 2025.

- Ensure, if possible by 2000, and from then on, that at least one-third of the energy requirements of central and eastern Canada is provided by energy resources indigenous to those regions, and that the remainder comes essentially from the energy-surplus regions of Canada (including the northern and offshore frontier regions).

- To achieve the above transformations in energy balances, energy prices in Canada are to increase to world energy price equivalence at least until costs of energy production in Canada, for supplies adequate to meet long-term Canadian energy requirements, are below world price equivalence.

- Achieve price differentials among energy resources to support the requisite substitutions of indigenous energy resources in place of imported oil, and do so on a sound economic basis.

- Ensure that the energy transformations are used as the basis of new industrial, employment and international trade policies, and to support Canada's contribution to developing countries.

- Bring into place energy reports, accounts and budgets, and a system of communications to permit widespread participation by Canadians in the National Energy Program.

Recommended programs

Current initiatives and recommended programs[1]

Many initiatives are being taken by the federal and provincial governments, by industry and others which contribute incrementally but significantly to the adjustment process. For example, many current activities relate to space heating and fuel economies. In this "Futures" report, a national heating program is recommended as a comprehensive way to implement programs, progressively through time, to meet the nation's heating needs by taking full advantage of new combinations of fuels and greater heating efficiencies. The program would be carried out locally, provincially and regionally, and integrated at the national level. Many current programs or planned programs contribute significantly to such a national heating program. The Canadian home insulation

1 See Appendix 4 for a more detailed examination of current, federal government initiatives within the context of the recommended programs.

program (CHIP), emphasis on new furnace design, new building standards, experimentation with solar heating, and studies of co-generation and of district heating schemes are individual, but related, activities. The recommended national heating program would integrate those activities into comprehensive, new approaches to space heating over a longer-term future, involving also different mixes of energy supply.

Much the same close relationship exists between other current activities and the recommended programs of the "Futures" report. For example, within the consolidated energy supply program, efforts are being made to extend the use of heavy oils and oil sands, expand the marketing of natural gas, manage effectively the residual oil supplies of central Canada, assess changes in refinery operations, determine the feasibility of various pipe-line and other transportation systems from the Arctic regions, and to bring on renewable resources and byproduct forms of energy. Individually, these efforts all contribute to the consolidated energy supply program. That program would assess the overall supply potential, the possible timing of results from each program and how that would fit with new patterns of demand. It would also attack outstanding constraints (such as institutional or financial shortcomings, or environmental considerations), assess what the overall impacts will be on achieving satisfactory energy balances, add other complementary long-term programs, and consider revisions to targets or programs, and their implications. Although each program and individual component can proceed independently, a satisfactory energy adjustment requires that each be evaluated within a comprehensive framework. Other priorities (including economic and social), gaps in the programs and the need for revision in scope or timing will then be more apparent. Cross-impacts and other broad implications can be systematically investigated.

The main purpose of the recommended programs, in support of the above indicative targets, is to ensure that satisfactory energy balances are achieved and maintained from now through 2025. Because of the all-pervasive nature of the required participation, no recommendations are included concerning jurisdictional responsibility. Some necessary procedures are apparent. For example, to ensure widespread participation and the coordination of activities, <u>a national energy information and participation program</u>, to serve all groups, is essential. The federal government, working in close consultation with the provincial governments and with industry and other interested participants, would have the lead role in coordinating and initiating these activities.

The recommended programs support the five policy elements referred to earlier: end-use transformation, consolidated supply, facilitating the adjustment process, realizing economic and social opportunities, and the information and participation requirements. A schematic presentation of the recommended programs is given in Figure 13-2. The manner in which current initiatives relate to the recommended programs is shown in Appendix 4.

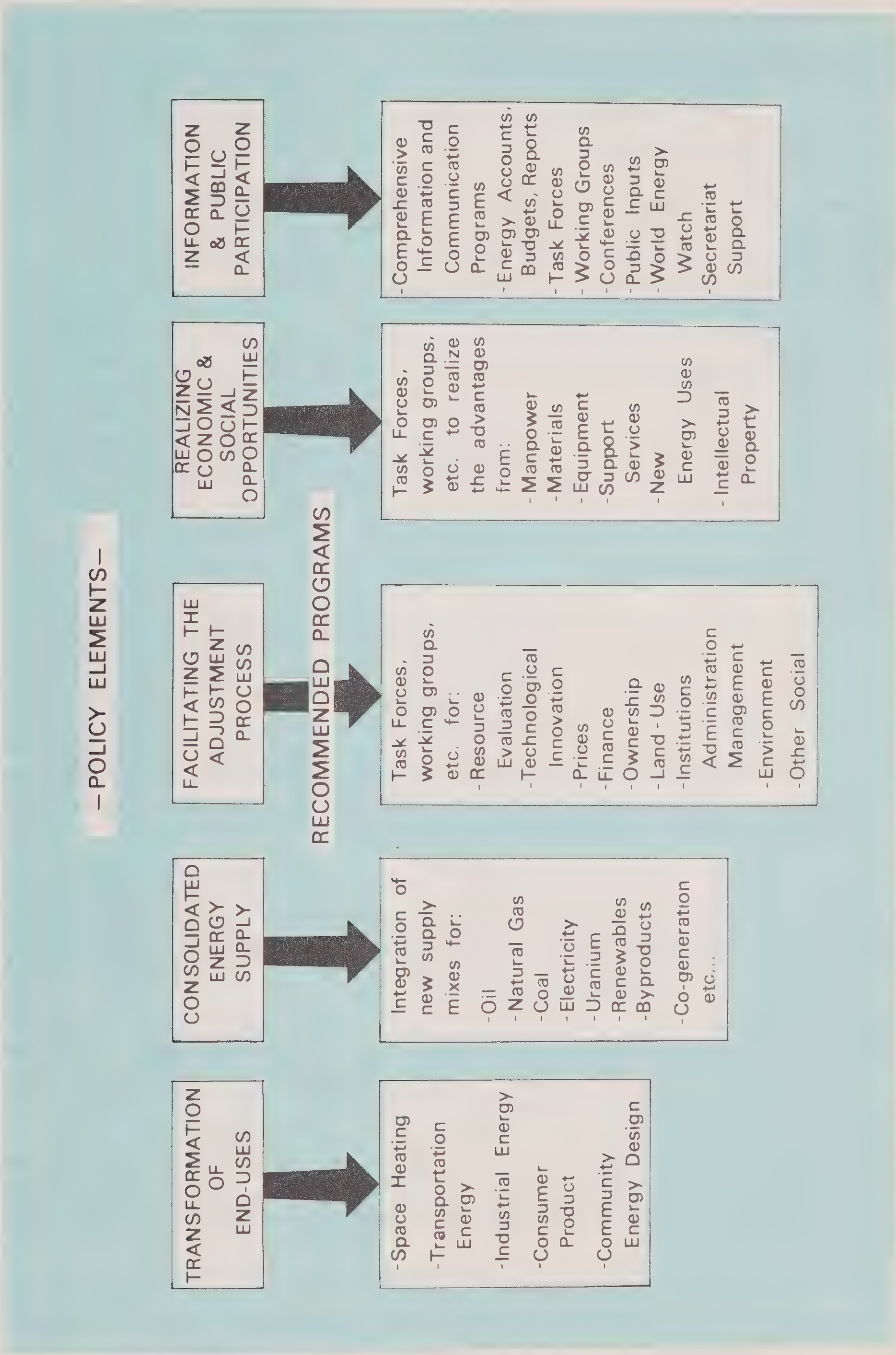

Figure 13-2. Principal recommended programs.

RECOMMENDATIONS

1. Transformation of end-uses

Transform energy end-uses to conform to the energy we can have from Canadian sources.

National space heating (space conditioning) program -- (principally low-temperature heat)

Program objectives:

- implement and extend programs which, over the long run, will increase overall heating efficiency by 50 per cent; and

- implement and extend programs to virtually eliminate oil from space heating by substituting natural gas, electricity, renewables and byproduct heat, co-generation and district heating, as appropriate in the different regions.

Recommended actions:

- to improve space heating efficiency, present programs, including insulation and other retrofitting be vigorously pursued and extended; energy-efficient building standard codes be adopted for new buildings;

- recently instituted programs to establish minimum standards of efficiency for new heating equipment and programs for improving the efficiency of existing equipment be vigorously pursued and extended;

- a national space heat audit be instituted to identify local and provincial opportunities to use local and other Canadian-supplied fuels, with particular emphasis on natural gas, district heating, co-generation, renewables, byproduct energy and electricity;

- programs be instituted, initially as pilot and demonstration programs, to make use of multiple-fuel possibilities, with particular regard to seasonal and local availability;

- programs be instituted, initially as pilot and demonstration programs, to demonstrate the feasibility and advantages of extensive heat storage (particularly seasonal) and heat transfers;

  a) ensure that institutional and regulatory capabilities are established to deliver <u>heat</u> rather than a specific fuel; and

b) where possible, attempt to accomplish the objective of a) through existing utilities or other existing institutions.

Energy-efficient transportation program -- mobile energy (to include structural, modal and inter-modal change)

Program objectives:

- extend programs to limit the share of transportation energy demand to 25 per cent or less of total secondary energy demand by extensive increases in efficiency, including new equipment and new combinations of transportation systems; and

- substitute out 25 per cent of oil from transportation by electricity, other liquid fuels, hydrogen, etc.

Recommended actions:

- continue and increase efforts for energy conservation and greater efficiency in transportation by mileage standards, tax penalties for inefficient vehicles; by automobile fuel-efficiency labelling, lower road speed limits; encourage economies through capacity loading in air travel and all modes of freight haulage;

- thoroughly re-assess regulations, licensing, insurance, labour and management practices so as to encourage energy efficiency, for example, re car pooling, back-hauls and pick-up services by company truck fleets; incentives for car rental of larger vehicles for long-distance travel, use of "commuter" and "shopping" carts with designated traffic lanes;

- task forces and other groups to investigate in detail further conservation and efficiency measures and also structural changes, for example, along the following lines:

  a) new passenger transport vehicles, including electric, short-distance, special purpose vehicles for urban freight, commuting and shopping;

  b) more energy-efficient freight vehicles (road and rail);

  c) re-design urban commuter transit systems and rationalize other transportation modes, regulations and institutions to increase by perhaps 25 per cent the energy efficiencies of freight haulage;

  d) establish economic, liquid fuels and other combinations of fuel products to reduce gasoline consumption;

e) electrification of railroads, earth-moving, pipeline pumps, agricultural and other industrial haulage; and

f) increased use of communications, store deliveries, staggered hours and days of work and similar lifestyle changes for energy efficiency.

Industrial energy program -- (high-temperature process heat and stationary drive)

Program objectives:

- reduce by one-half the energy required per unit of industrial production;

- substitute other energy resources for oil to eliminate one-quarter to one-half of the oil requirements of the modified industrial energy demand;

- develop industries to supply the requirements of the energy transformation; and

- promote structural changes to take full advantage of the industrial and other economic and social opportunities arising from Canada's growing comparative advantage in energy and in specialized energy technologies.

Recommended actions:

- continue and increase actions to audit energy performance by industry and to encourage the adoption of energy-efficient production methods;

- continue and increase actions to encourage the production of byproduct energy, co-generation and other energy producing activities; for example by sales tax exemptions, capital cost allowance, energy pricing, institutional, regulatory and management changes;

- ensure a high degree of energy efficiency in the rapidly growing and new types of energy production and in the non-energy uses of energy resources; and

- achieve a substantial substitution of other fuels for oil in industrial use.

Consumer products energy program -- (lighting and appliances -- efficiency, labelling, durability, re-cycling, etc.)

Program objective:

- reduce by at least one-quarter the unit energy requirements in household appliances and lighting.

Recommended actions:

- increase activities for energy-efficiency labelling and increased energy efficiency in appliances, space conditioning and lighting equipment; particular attention to be paid to these factors in rental accommodation;

- increase the durability of appliances, their recycling or scrappage value, and the ease of their repair and maintenance (for example, by greater standardization of, and use of, modular parts for ease of relacement, establishment of "one-stop" service centres; greater use of appliance and equipment rentals);

- establish energy-saving audits for households, commercial, industrial and public buildings, with particular attention to increasing public awareness; and

- establish task forces and other groups among consumers, equipment and appliance suppliers, and others to design and promote energy efficiency.

Community energy design program -- (a consolidated, community "enterprise" approach to efficient energy use in urban, rural and remote communities and in the inter-community linkages)

Program objectives:

- to establish, through re-design and structural change, further increases in the energy efficiency of communities beyond those achieved by the specific programs for space heating, industry, transportation and consumer products; to bring into effect a consolidated community energy program.

Recommended actions:

- conduct community energy audits with a view to identifying major economies from community re-design, the design of new communities and other energy rationalizing measures;

- increase the energy self-reliance and energy complementarity of communities; and

- identify energy savings in inter-community linkages, travel and freight haulage.

End-use programs as a whole

The above programs call for greatly altered patterns of energy use, to reduce unit energy requirements and substitute other resources for oil. The programs require substantial re-organization

of distribution, marketing, pricing, institutions and personal habits to meet new supply capabilities on a local, provincial, regional, national and international basis. It is essential to recognize that these are energy-balance programs, not just conservation programs. They involve the progressive introduction of structural changes in demand, supply, support systems and institutions, geared to the particular needs and opportunities of each community and province, coordinated within regional and national programs.

2. Consolidated energy supply

The objective of the consolidated energy supply program is to establish and maintain, in a flexible, dynamic way, an appropriate mix of indigenous energy supplies for Canada as a whole, each province and region. The programs for new energy balances are designed to exploit the energy which we can have in the future rather than what we have been accustomed to having in the past. To integrate new supply components into the new energy balances involves the elimination, where possible, of apparent conflicts in the marketplace (e.g. residual oil and natural gas; electric utilities and co-generation). It thus requires the maximization of supply complementarities by, among other things, introducing the necessary institutional and regulatory changes, ensuring full industry and public participation, and facilitating the price, financial, manpower, equipment and materials support adjustments. The energy balancing process will continue to rely upon international trade in energy resources and in energy-related goods and services. The international relations are dealt with under 4. Realize economic and social opportunities.

The indicative targets listed earlier in this chapter demonstrate important shifts in energy demand toward new supply capabilities -- a reduced share for oil, especially imported oil; a constant or increasing share for natural gas; a substantial increase in electricity, particularly nuclear power and coal-fired thermal generation; an increase in other uses of coal, and in the use of renewables and other supportive forms of energy. The program targets in this section are resource - specific -- i.e. they deal with each energy supply resource separately.

Recommended actions however, are not specified for each resource. The actions are implicit in the objectives. More detailed investigation by task forces and other groups will provide detailed action, and will indicate how those actions might be staged appropriately, especially over the next 25 years. The general recommendation, therefore, is that task forces and other working groups be established to assess and program the requisite combinations of energy supply projects.

A start in the consolidated energy supply program can be made with any resource, or by actions taken on many of them at the

same time. Following the outline of individual resources, an illustration is given of how natural gas might be used as one strategic starting point into the consolidated energy supply program.

Oil

Program objectives:

Increase oil production by more than 50 per cent, to 2.5 million barrels per day by 2000, and maintain that level to 2025. To meet the above objective would require some combination of:

- about 10 oil sands surface mining plants by 2000, possibly 2 in situ oil sands plants and 2 full-scale, in situ heavy oil production units, with requisite processing facilities; these units to be increased and replaced as necessary between 2000 and 2025;

- possible additional supplies of oil from conventional areas as a result of further exploration and the use of secondary and tertiary recovery methods;

- possible supplies of oil from frontier areas as a result of extensive exploration and geological evaluations.

These oil targets are extremely difficult to achieve even if agreement can be reached on their acceptance. For example, a new oil sands plant (surface or in situ) would have to come into production every 18 months or 2 years compared with 5 or 6 years at present -- roughly, a 3-fold acceleration in preparation, financing and installation. Provincial acceptance, environmental impacts, financing, manpower, equipment, materials, infrastructure and service requirements should, therefore, be approached on that basis.

Natural gas

The consolidated energy supply program could begin by an assessment of how an additional, assured supply of natural gas (a natural gas wedge) could be worked into the markets of central and eastern Canada. This program supports the indicative target of maintaining or increasing the share of natural gas in total energy use throughout the next 50 years.

Program objectives:

- increase natural gas production by approximately one-third, to supply at least 3,200 billion cubic feet per year by 2000, and increase that production further to 2025;

- develop additional markets, particularly in central and eastern Canada, on the basis of a 30-year assured supply of natural gas as provided by the increased production; and

- integrate the gas supply with new patterns of energy use and complementary sources of supply.

Recommended actions:

- ensure that the requisite natural gas supply is available over a 30-year period; increase efforts to establish long-term production and deliverability, based first upon proven conventional natural gas reserves; then, as feasibility is demonstrated, from new types of formations and deposits in western Canada, from the northern frontier regions and the offshore east coast;

- encourage further exploration to identify natural gas reserves; provide for the necessary financial participation and, as necessary, for advance purchase and storage, short-term gas exports and interruptible domestic supply arrangements;

- provide the complementary delivery systems such as the extension eastward of the natural gas pipeline, western Arctic and eastern Arctic pipelines, LNG facilities as required;

- ensure that distribution and consumer facilities are developed to use the additional supplies of natural gas, and that pricing policies and institutional arrangements are fully supportive of using the additional natural gas in ways complementary to the other, particularly the indigenous, energy supply capabilities; and

- assess the additional supply capabilities from the temporary importation of LNG, the production of SNG, coal gas and hydrogen.

Coal

Program objectives:

- increase total coal production about 4-fold to 2000 (to 120 million tons), and at least double it again by 2025;

- within the above target, increase thermal coal production nearly 8-fold (to about 100 million tons) by 2000, and by a further 60 per cent by 2025;

- develop the technologies and support facilities to expand the use of coal into industrial uses, into SNG and liquid fuel forms, and for use in fluidized beds; and

- establish the requisite transportation facilities, environmental standards and protection capabilities to support the very much larger use of coal.

Electricity

Program objectives:

- increase electrical generating capacity nearly 4-fold to the year 2000, and by a further 25 per cent to the year 2025;

- transform patterns of energy use to increase the share of electricity to about 50 per cent of total primary energy requirements by the year 2000, and to 55 or 60 per cent by 2025;

- base the increased electricity generation principally on expanded hydro, coal and nuclear power, with the expectation that nuclear power will become dominant among the three beyond the turn of the century;

- expand as much as practical electricity generation from solar power, biomass, waste heat sources, low-head hydro sites, tidal and wave power and co-generation; and

- develop as rapidly as possible advanced electricity storage systems, load-levelling programs, regional, national and international electricity grids, advanced transmission systems and compact energy, transportation and communication corridors.

Uranium, thorium and nuclear

Program objectives:

- develop nuclear power so that, by the year 2000, it is capable of providing about one-third of Canada's very much greater electricity requirements, and a higher proportion by 2025;

- conduct exploration and geological evaluation programs on an accelerated basis to provide a long-term assured fuel supply;

- give high priority to nuclear waste management and to perceptions of hazards which might delay or prevent a satisfactory deployment of nuclear power;

- be able to deploy commercially, by the year 2000, the thorium fuel cycle or some variant of a breeder fuel cycle; possibly bring into commercial operation before the year 2000, the organic-cooled reactor for high-temperature,

high-pressure steam; assess the useable heat potential of nuclear power in addition to its electricity potential, and investigate the feasibility of small size nuclear reactors; and

- ensure that future nuclear installations are supported by a 30-year assured fuel supply.

Renewable resources and other energy resources

Program objectives:

- develop the most appropriate combination of renewable resources to supply 5 per cent of Canada's primary energy requirements by 2000, and 10 per cent by 2025[1]; those quantities are respectively equivalent to about 400 000 and one million barrels of oil per day;

- establish, as early as possible, the economic feasibility of the various renewable resources, and the institutional, regulatory, management and marketing changes which would be required for the extensive deployment of renewable resources, byproduct energy, urban wastes, peat, hydrogen, co-generation, fluidized beds and district heating systems into energy uses; and

- establish extensive pilot and demonstration projects for renewable and other energy resources, widespread across Canada, but with special attention to the energy-deficient regions of central and eastern Canada.

Energy storage and transportation

Program objectives:

- establish and enhance both temporary and long-term energy storage capabilities for energy resources, to provide resiliency, flexibility and an assured supply consistent with the required energy transformations;

- provide for "storage in place" (e.g. proving, financing, but not immediately exploiting oil, natural gas, coal, wood and uranium reserves); storage in natural caverns (abandoned mines, caves or salt domes); storage as waste, re-cyclable produce (nuclear fuels, urban wastes, sawdust, oil residues

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1 These amounts are additional to the significant supplies of renewable resources which are now in use, but which are not usually included in energy estimates; an improved set of energy accounts is required.

or re-cyclable oil and other products); fabricated storage (pumped hydro facilities, storage tanks and silos); surplus capacity (electricity generating capacity); latent supply capability (storage batteries, flywheels); and

- put in place additional, efficient energy transportation systems consistent with the new, future energy balances, and facilitate the energy transformations -- for example, by frontier oil and gas pipelines, new distribution systems, coordinated electricity grids, new transportation technologies (e.g. slurry pipelines).

Consolidated supply program as a whole

The above programs are expressed in terms of individual energy resources. Each program can proceed more or less independently of the others. However, the basic concept of the consolidated energy program is that satisfactory energy balances will require careful integration of these resources. Patterns of use will be changed to accommodate the new supply capabilities. Thus, the prime objective of the consolidated energy program is <u>to investigate and develop the appropriate complementarities of energy supply and demand</u> in each locality, province, region, for the nation as a whole and in respect of energy-related international activities. One approach to establishing an integrated energy supply is illustrated below. The process begins, in this illustration, by bringing additional natural gas supply to the markets of central and eastern Canada. Other supply capabilities are then integrated with that natural gas objective within a consolidated energy program. Other resources can similarly be used as a starting point, and the program reconciliations carried out. Another particularly useful starting point, at the local, provincial and regional levels, are the indigenous resources of that location to which other resources are then added in a complementary fashion.

Consolidation steps

- establish a capability to provide a 30-year assured supply of natural gas for an increased market, particularly in central and eastern Canada, by:

  a) ensuring that the market facilities and appropriate prices and institutions are present to permit the penetration of natural gas into those markets;

  b) ensuring that supplies and pipelines are available to cascade gas into the market -- perhaps first from the enlarged, conventional Alberta reserves, then from new gas formations in western Canada, Mackenzie Delta and Beaufort Sea, East Arctic (LNG tankers and/or Polar Gas Line), possibly Labrador and other offshore east coast; and

c) possibly supplement the above natural gas supplies, for a time, with imported LNG, then with SNG, coal gas and hydrogen;

- integrate the incremental gas supply with indigenous renewables, co-generation and byproduct heat, district heating, tidal and wave power, other electricity and regional coal;

- develop complementary natural gas and residual and heavy oil programs by changing refinery processes and possibly by exporting temporarily surplus petroleum products and natural gas;

- integrate the natural gas and residual oils with the heavy oil programs, and with production of oil from the oil sands and frontier regions;

- integrate the oil sands production with the coal requirements of the oil sands, possibly introducing organic-cooled nuclear reactors for high-pressure steam for the oil sands and heavy oils;

- assess the above coal requirements in conjunction with thermal coal for electricity generation, for SNG and liquid fuels production, and coal for metallurgical and other industrial uses in Canada and for export;

- assess the thermal-electric coal requirements in conjunction with hydro, nuclear, biomass, wind, solar, co-generation and other electricity generating capabilities; and

- establish from the above, the best combinations to meet the greatly changed energy needs of the provinces, region and the nation, taking into account also international energy relations and the economic and social opportunities in each region.

3. Facilitate the adjustment process

Ensure that factors of adjustment (such as prices, financing, ownership, environment, innovation), individually and collectively, support the energy transformations which are necessary over time, to achieve and maintain satisfactory energy balances.

Detailed recommended actions cannot be given for all of the critical adjustment factors. The following, general recommended actions apply to all of the adjustment factors:

General

Program objective:

- task forces, committees and working parties be established, and remain in operation, to advise how the factors of adjustment, individually and collectively, can be made fully supportive of the energy programs which are necessary to achieve satisfactory energy balances on a continuing basis.

Recommended actions:

- the task forces and other groups to be made up of senior decision makers from industry, financial institutions, governments, labour organizations, energy users, international experts, special and local interest groups, and other representatives of public interests; and

- the task forces and other groups to bring to bear the best expert knowledge on resource availability, technological and economic feasibility, jurisdictional, institutional and organizational capability, and on social or public acceptability; that specific constraints and opportunities be addressed within the framework of the evolving energy situation, including the medium and long-term prospects, the objectives and targets; that the task forces and other groups help to establish the priorities, the timing and the implementation of programs to deal effectively with the changing situation, the prospects, the objectives and the targets.

Prices

Program objectives:

- establish energy prices in Canada at world energy price equivalence until the economic cost of production of sufficient Canadian energy to achieve and sustain energy self-reliance is below world prices;

- establish price differentials among energy resources to encourage the use of indigenous resources, particularly in the energy deficit regions of Canada; such differentials to be established, as far as possible, on sound economic costing bases;

- ensure that the complex pricing practices throughout the various supply and demand patterns support as fully as possible the objective of sustainable self-reliance in energy, thus providing the basis upon which adequate financing of energy projects can be built; and

- ensure that, as far as practical, energy pricing practices follow sound economic criteria, and that the reasons for any deviations to meet other objectives are explicitly stated, and assessments of their impacts are made public.

Recommended actions:

- extensive investigations be undertaken by task forces and other groups to ensure that price performance and pricing policies are as consistent as possible with the targets; to assess the probable future price impacts and the necessary offsets and adjustments if prices and pricing policies are not supportive of the targets; and

- prices task forces and other groups work closely with those for energy financing, ownership and control, and with other energy programs, to ensure that the total efforts are as consistent as possible.

Financing, ownership and control

In Chapter 10 it was noted that conditions of financing, ownership and control for energy projects will be substantially different in the future than in the past. The financial requirements cover a much expanded range of energy-related activities previously not explicitly included within the scope of energy investment. Moreover, the transformation in energy balances will impose new financing pressures, in terms of scale and in terms of new, energy-related activities, which the existing sourcing and application of funds have not been called upon to meet. These changes require considerable financial innovation, involving new approaches to risk-taking, to financial incentives, to rates of return, to the sourcing of funds, as well as to ownership and control. The result will be new approaches to the pooling of funds from private, Canadian and international sources, as well as from governments. The following program targets and recommended actions illustrate an approach to those differences and to the substantial financial requirements of the energy sector.

Program objectives:

- ensure that the financial incentives and the financial institutions and services of the private sector, together with complementary government financial resources, are modified to support the increased financial requirements of the new energy balances;

- ensure that conditions of ownership and control support energy financing and satisfactory energy balances; and

- establish processes of financing, ownership and control which are conducive to the largest, practical participation

by Canadians, but which also provide adequate incentives for financial participation by non-Canadians.

Recommended actions:

- the necessary task forces and other groups be established to assess and implement, as far as practical, the above targets; and

- the task forces and other groups examine, in particular, innovative approaches to risk sharing, uncertainty, external factors, technological innovation, experimental and pilot projects, market penetration by new energy sources, and the integration of energy uses and supply -- such innovations to include, for example, new forms of financial instruments (e.g. revenue bonds) and joint-venture financing including international financing, revolving investment funds, new ways of attracting widespread, public financial participation, new ownership and control processes which provide incentives to widespread financial participation.

Technological innovation (RDD&D)

Program objectives:

- ensure a Canadian capability to provide, or to assess, the full range of technological innovations which will be necessary to achieve the new energy balances;

- increase substantially in amount and in coverage the RDD&D activities necessary for objective above; and

- move RDD&D activities forward systematically around the priorities which emerge from staging in the new energy balances.

Recommended actions:

- concept of energy RDD&D be greatly broadened and the priorities assigned to it be greatly increased to take into account all constraints which impede appropriate energy transformations (for example, technological, prices, financing, manpower, environmental, public concerns);

- research priorities include investigation of the programming and timing of the technological innovations through to their deployment as a significant part of the National Energy Program; comparative, evaluative techniques be used to assess technological priorities;

- a wide range of highly innovative pilot and demonstration projects be encouraged across Canada to accelerate

introduction of new technologies in the face of new kinds of financial and marketing risks, and to take advantage of perceived opportunities.

- investigations to include an extensive examination of RDD&D financing from all sources in Canada, with a view to increasing, within the next three to five years, at least by a factor of four, the funds being made available to energy-related technological innovations; these investigations to include also how to increase or marshall the expert manpower, equipment and other requirements into well-managed innovative efforts.

- fullest possible participation by Canada in international efforts for technological innovation be encouraged, especially in those technologies which are assigned a high priority in Canada's National Energy Program.

Environmental, health and other social objectives

Program objective:

- ensure that environmental, health and other social objectives are taken fully into account not only in respect of individual energy projects but for entire energy systems; that assessments be carried out well in advance of project and systems implementation to ensure their acceptability and to prevent unnecessary delays, uncertainties, cancellations or late design changes made necessary because of inadequate advance information on environmental and other social concerns.

Recommended actions:

- environmental and other social concerns be investigated systematically and comprehensively by groups of impartial, expert evaluators to assess both the immediate and the probable long-term impacts of individual projects and of entire energy systems (for example, the environmental stress imposed by 12 oil sands plants rather than that imposed by the next incremental plant, or of 20 nuclear plants, or of large-scale forest biomass and solar projects);

- provision be made to ensure that continuing evaluations are being made;

- environmental and similar social evaluations include well organized public participation with systematic, evaluative criteria, the results to be made public;

- evaluations be carried out, as far as practical, at early stages of project or systems design; enquiries be conducted expeditiously so that project modifications may be made, as required, without undue delays to the undertaking; and

- comparative evaluations be encouraged so that the respective merits of one alternative can be examined in relation to others, and in recognition of the necessity to deliver, within a specified period of time, quantities of energy from one resource or another, and that patterns of use be modified to ensure satisfactory energy balances at all times.

Institutional capability -- (including also jurisdictions, regulations, administration and management)

Program objective:

- ensure that jurisdictional arrangements, institutions, regulations, administrative procedures and management arrangements are revised in ways which support the achievement of the requisite energy transformations; that bottlenecks and constraints in these procedures be systematically removed to prevent unnecessary delay or uncertainty in the deployment of energy programs.

Recommended actions:

- institutional assessments be carried out by different groups in society to identify gaps, inefficiencies, apparent contradictions and possible opportunities for improvement within the jurisdictional, institutional, regulatory, administrative and management relationships with a view to ensuring that these activities effectively support future energy transformations; these constraints be evaluated and dealt with in a functional manner in terms of specific programs, targets and objectives; and

- re-organization of these activities to integrate the dispersed inputs of governments and private sectors in all parts of Canada to be fully supportive of the energy programs.

Manpower, equipment, materials and infrastructural requirements

Program objectives:

- ensure that the requisite manpower, with the appropriate training, skills and organization is available when and where needed, and that community conditions and conditions of work support energy transformations; and

- ensure that the equipment, materials and infrastructural requirements are available where and when they are required, and that opportunities for the supply of these requirements from Canadian resources are fully exploited as a result of advance preparation.

Recommended actions:

- task forces and other groups examine long-term manpower, equipment, materials and infrastructural requirements and their probable availability from Canadian sources; these activities to include, for example, inventories of the probable required skills, necessary training programs, labour union participation; machinery and equipment requirements;

- investigations to emphasize the opportunities to increase Canadian production and employment in the support activities and in new industrial ventures in all regions of the country; and

- investigations to identify the appropriate timing and programming of the supply requirements of energy-related projects to eliminate avoidable bottlenecks and to assess the indirect effects of the manpower, equipment and supply requirements on the nation.

4. Realize economic and social opportunities

Program objective:

- achieve the economic and social benefits inherent in bringing about the energy transformations and in using the transformed energy system.

Recommended actions:

- manpower, equipment, materials and infrastructural requirements of the energy transitions be thoroughly assessed by relevant groups to identify and pursue the opportunities for increased Canadian participation in the support activities;

- investigations be carried out, particularly by the principal energy-supply industries and the energy-user industries, to identify the economic and social advantages to be gained from the energy transformations and from Canada's potential comparative advantage in energy resources; included in these investigations, for example, would be new industrial and export opportunities; employment, incomes, and regional development opportunities; new community development projects, land use, and environmental protection innovations;

- investigations be undertaken by the expert and skilled persons most involved of how the greatly expanded innovative efforts (the intellectual capital) can be used regionally, nationally and internationally to Canada's advantage, and as part of Canada's contribution to developing countries; and

- the principal economic and social opportunities to Canada from its <u>international energy relations</u> be realized in the following way:

  a) reduce Canada's imports of oil to not more than 10 to 15 per cent of Canada's oil requirements by the year 2000, and reduce oil imports to negligible amounts by 2025;

  b) regain an export surplus in energy-related goods and services by 2000, and increase that balance by 2025 (the assumption being that the present export surplus in energy resources will be replaced by a trade deficit within the next few years);

  c) industrial and economic policies be adopted to take advantage, in international trade, of Canada's comparative advantage in energy beyond 1985;

  d) technological innovations, energy-related skills and equipment be established to contribute to a significant export surplus in energy-related goods and services before 2000;

  e) ensure that conditions in Canada are conducive to the inflow of foreign capital as required to finance energy-related projects; develop innovative approaches to finance, ownership, control, industrial development and marketing to assist in this requirement;

Many new industrial opportunities will arise from Canada's favourabe energy supply position.
(Imperial Oil Limited)

f) a world energy watch program be established to ensure that the potential impacts of world energy developments on Canada's future are being continually and systematically assessed;

g) maximum benefit be obtained from international energy-related R&D through Canada's active participation in those R&D programs which are relevant to Canada's needs; and

h) programs and technologies designed for energy transformations in Canada be made available, as appropriate, to developing countries as a contribution to working with them to overcome their energy problems.

5. Energy information and participation program

Program objectives:

- ensure that Canada's long-term energy future is given high priority on the agenda of the nation and that decisions in all parts of the country are based on the fullest possible information;

- ensure that the public is aware of the national threat posed by the evolving energy situation in Canada and abroad, and that the public is continually able to evaluate the implications of the changing developments;

- help to make fully effective the coordination of energy-related programs initiated by governments, industries, utilities and by others, in all parts of Canada;

- assist members of the public to appreciate how their active, responsible participation in energy-related activities contributes to a satisfactory energy transformation; and

- ensure that up-to-date information is always available to participants in all parts of the country to permit meaningful discussion, debate, evaluation and participation in energy-related programs.

Recommended actions:

- priority be given to the establishment of comprehensive information and communications programs to achieve widespread public participation in the energy transitions, and to permit widespread public understanding of, and support for, those processes;

  information and communications programs include widespread, active exchanges of information to ensure the coordination of program initiatives;

- national energy secretariat be established as an information utility to all participants -- to receive, organize, analyze, and make available information on energy-related activities in Canada and abroad; that a world energy watch program be a part of the information assembly;

- information and communications programs to make full use of energy state of the nation reports designed to keep Canada's energy future a matter of first importance on the agenda of the nation;

- state of the nation reports, and other information and communication activities, be supported by a set of long-term energy targets and objectives, interim performance targets and indicative timing and staging of programs, processes of audit, evaluation, and program revision, all of which to incorporate public discussion, debate and participation;

- information and communication program be fully supported by widespread analytical activities, these to include, for example, national energy budgets, national energy accounts (analagous to the national income and expenditure accounts of the gross national product), supporting energy-related analytical models and energy/economic/social accounts and analytical models;

  all reports, accounts, models and targets mentioned above to have provincial and regional components as appropriate, and be made public; and

- information and communications programs benefit from the continual participation of committees, task forces and groups which are continually investigating, recommending and implementing various parts of the National Energy Program; for example, significant inputs would come from those task forces and committees which are brought together within the five sets of programs of these recommended actions and of the related strategic issue areas (identified in Appendix 3); a full set of media presentations and educational programs be included.

Recommendations as a whole

The above recommendations are designed to ensure that the long-term, future energy transitions for Canada and for the world receive high priority in the nation's business. Although each recommendation can be acted upon separately, the recommendations are a composite package. They are a response to the future. Taken together, the recommendations are designed to lead Canadians

closer to a National Energy Program -- a coordinated approach to our long-term energy future, and to its great economic and social implications. That approach represents a major extension of national purpose: to deal effectively with a third dimension of time -- the long-term future.

The recommendations and the report deal with a future stretching out for 50 years. <u>That is not a remote future</u>. <u>It begins now</u>. To assume that concerted effort on these recommendations and on a National Energy Program can be set aside for 5 or 10 years will be to ensure that Canadians will face greater difficulties of adjustment and greater economic and social stress. To build now systematically upon the initiatives which already are being taken will be to provide a new national purpose centred on one of the most dynamic, potentially disruptive or potentially enriching forces in Canada's future.

Appendix 1

GLOSSARY

Contents of glossary

Acronyms

AERCB - Alberta Energy Resources Conservation Board

AECB - Atomic Energy Control Board

AECL - Atomic Energy of Canada Limited

AOSTRA - Alberta Oil Sands Technology and Research Authority

CERI - Canadian Energy Research Institute

CIDA - Canadian International Development Agency

CMHC - Central Mortgage and Housing Corporation

EEC - European Economic Council

EMR - Energy, Mines and Resources Canada

ESAB - Energy Supplies Allocation Board

FIRA - Foreign Investment Review Agency

GCOS - Great Canadian Oil Sands Company Ltd.

IEA - International Energy Agency of the OECD, Paris

IIASA - International Institute of Applied Systems Analysis, Vienna

LDC's - Lesser developed countries

NEB - National Energy Board

NRC - National Research Council of Canada

OECD - Organization for Economic Co-operation and Development. Members:

Australia	Finland	The Netherlands
Canada	France	Norway
Japan	Fed. Rep. of Germany	Portugal
New Zealand	Greece	Spain
USA	Iceland	Sweden
Austria	Ireland	Switzerland
Belgium	Italy	Turkey
Denmark	Luxembourg	United Kingdom

OPEC - Organization of Petroleum Exporting Countries:

Iran	United Arab Emirates	Gabon
Iraq	Ecuador	Nigeria
Kuwait	Venezuela	Libya
Qatar	Algeria	Indonesia
Saudi Arabia		

UN - United Nations

Definitions

Atomic or nuclear energy: All energy of whatever type derived from or created by the transmutation of atoms. See breeder reactor, CANDU, fission/fusion, and nuclear wastes.

Biomass: Unfossilized material of biological origin. Organic compounds which are embodied in biological materials and produced by living organisms, for example, wood, other vegetation and animal excrement.

Bitumen: Asphalt. See oil sands, recovery methods.

British Thermal Units: See energy units Btu.

Breeder reactor: In the breeder reactor "fissile material" is produced at a faster rate than it is consumed. Examples of such reactors are the liquid metal fast breeder reactor (which consumes plutonium while producing it from uranium) and the thorium cycle CANDU (which consumes uranium 233 while producing it from thorium).

Byproduct energy: See co-production, co-generation, district heating.

CANDU: The Canadian nuclear reactor system which is moderated by heavy water (deuterium) and is fuelled by natural uranium. The name is derived from CANada, Deuterium and Uranium.

City-gate price: The unit price charged by the transmission company for natural gas transported via pipeline to a distribution company in a particular city or area, e.g. Toronto.

Coking coal: Coal which meets specific processibility criteria and which has sufficiently low contaminants for the production of metallurgical coke, essential to the manufacture of steel.

Co-generation: The generation of electricity by increasing the temperature and/or pressure of heat required for process use, extracting part of the heat for electricity production and discharging the remainder at appropriate conditions for process requirements.

Co-production: A generic term indicating that more than one useful form of energy is producible from the same facility.

Conventional oil: Crude oil recoverable from a well using standard production techniques. See recovery methods.

Conversion loss: The difference between the energy available as an input to the conversion process and that available for use as "secondary energy".

Crude oil: Petroleum which enters the refinery, subject to quality grading and commensurate price variations.

Demonstration: Technologies, equipment and methods which have reached a threshold of operational reliability that indicates commercial feasibility.

District heating: The supply of heat in the form of steam or hot water to a group of buildings from a central source, such as a dedicated thermal plant, or from co-production, co-generation or recycled or reject heat sources, for example, from industrial processes.

Embodied energy: The energy used as an input in the production of a commodity or service.

Energy self-reliance: To meet energy demands from domestic energy resources to such an extent that no serious dislocation would occur if external energy sources were eliminated.

Energy supply system: The interrelationships which provide for the production of energy, its conversion to useful forms, its transportation and utilization.

Enhanced recovery: See recovery methods.

Exajoule: 10^{18} joules (See energy units).

Fission/fusion: Fission is the splitting of atomic nuclei and fusion is the combination of two atomic nuclei. In both processes the mass yielded is less than the respective masses of the original nuclei. The lost mass is given off as energy.

Fire-flood: See recovery methods.

Fluidized bed combustion: A process in which combustible materials are introduced into a greater volume of hot inert particles, contained in a chamber and maintained in a state of turbulence by a stream of gas (air) from below during their thermal conversion. The process can be pressurized.

Frontier areas: Generally the undeveloped northern mainland, the offshore areas (east, west and Hudson Bay), the Arctic Islands (onshore and surrounding offshore) and the Mackenzie Delta-Beaufort Sea.

Forest biomass: Biomass derived from forest matter. Residues from forest harvesting and from pulp and paper and wood products industries; also wood harvested specifically as an energy source, possibly from plantations of rapid-growth species dedicated for energy production.

Fossil fuels: Any naturally occurring solid, liquid or gaseous fuel of a fossilized organic nature. See hydrocarbons, resource, reserve.

Fuel: Any combustible materials which give off heat; also materials which can be fissionized in a chain reaction to produce heat (atomic or nuclear energy).

Geothermal energy: Energy from natural "hot spots" in the earth's crust; associated with hot dry rock or large reservoirs of steam or hot water.

Gross national product (GNP): The total value of the goods and services produced by the nationals of a country during a specified period (usually a year). In this report comparisons are made over time after adjustment for the effects of inflation, usually by expressing GNP in terms of the purchasing power of "constant dollar" or "real" GNP (e.g. 1975 dollars).

Gross domestic product (GDP): The goods and services produced in a nation during a specified period (usually a year), usually measured at "factor cost" (the cost of factor inputs). (GDP refers to production <u>in</u> the country, GNP to production by nationals wherever they are located. Hence, earnings paid abroad are in GDP, but not in GNP, whereas income earned abroad is in the GNP but not in GDP.)

Heat pump: A device which transfers heat from a colder to a hotter reservoir by the expenditure of mechanical, electrical or thermal energy, when the primary purpose is heating the hotter reservoir -- a reversible refrigeration system which provides either space heating or cooling in relation to seasonal needs.

Heavy crude oil: Oil which is of high viscosity recoverable only to a limited extent (5 per cent) from the reservoir by using standard production techniques. (See recovery methods and synthetic crude oil.)

High-grade or high-temperature heat: Heat which exceeds 100°C (212°F).

Hydrocarbons: Organic compounds containing only carbon and hydrogen atoms in various molecular configurations. Those which occur naturally as fossil fuels include conventional light crude oil, heavy oils, oil sands bitumen, natural gas liquids, natural gas and coal.

Inexhaustibles: Energy sources which are virtually infinite in terms of their utilization in the foreseeable future, or which are replenishable. Includes the renewables; fission breeders and fusion nuclear energy. For purposes of this report, also includes coal because of the vastness of the earth's coal resources.

In situ: Literally means "in place" and refers to recovery techniques applicable in heavy oil and oil sands without removing conglomerates from location. See recovery methods.

Lignite: A type of coal in which the alteration of vegetable matter has proceeded further than in peat but not so far as in subbituminous coal and which, consequently, has a lower heat content per unit of weight or volume.

Low-grade (or low-temperature) heat: Heat which does not exceed 100°C (212°F).

LNG: Liquefied natural gas; natural gas which is cooled and maintained at -160°C as a liquid, reduced in volume nearly 600-fold; when shipped by tanker transport, it is typically vaporized at the receiving terminal for pipeline transport and use.

LPG: Liquefied petroleum gases -- propanes, butanes and propane-butane mixes which are a byproduct of crude oil and natural gas production, and of refinery operations. LPG's can be regarded as a subset of the natural gas liquids (NGL's).

Marginal costs: The costs of supplying the next unit of a commodity or service.

Mechanical drive: Application of energy to operate machinery.

Metallurgical coke: Derived from coking coal for purposes of processing metals (see coking coal).

Methane: CH_4 formed by the decomposition of organic matter (e.g. deep coal deposits). Methane is the major constituent of natural gas. See SNG.

Methanol: CH_3OH formed either synthetically or from the destructive distillation of wood. A light, flammable, poisonous liquid alcohol which can be used as fuel, for example, internal combustion engines; or blended with gasoline.

Mobile mechanical drive: Application of energy as the primary propellant of any vehicle or other mobile application.

Natural gas: Naturally occurring mixtures of hydrocarbon gases and vapours; mostly methane (CH_4).

Natural gas liquids (NGL): The complete range of volatile liquid hydrocarbons associated with production and refining of oil and production of natural gas. Includes LPG's.

Non-energy uses: Non-energy applications of materials typically used as energy resources (e.g. petrochemical feedstocks and certain fertilizer materials).

Nuclear wastes: Radioactive products of the nuclear fuel system; e.g. irradiated fuel (bundles) and reactor wastes which have accumulated in filters, or other devices and materials associated with operating and maintenance activities.

Nuclear waste management: Systems to use or dispose of nuclear wastes to eliminate or substantially reduce the risk of injury to the health of living organisms. Nuclear waste management involves:

- immobilization - encasing the radioactive products within a solid protective material (glass, ceramic, bitumen or metal) to protect against dissolution by water;

- storage - emplacement of radioactive material in a safe location with the intention of retrieving it;

- disposal - permanent placement of radioactive material with no intention of retrieving it;

- repository - an engineered site designed for disposal of radioactive material.

Netback: Net return to a producer from a market sale after royalties, taxes and transportation fees are deducted.

Oil sands (tar sands): Deposits of sands and clay (excludes oil shale) heavily impregnated with hydrocarbon compounds known as oil sands bitumen which does not flow.

Peat: The starting material in coal genesis; partly decomposed remains of marsh vegetation requiring approximately 7 000 years to reach the stage known as peat.

Petroleum refining: The separation of the different petroleum (crude oil) hydrocarbons into groups and their conversion into marketable products. It includes processes for increasing the yield of desired hydrocarbons and methods for purifying the resultant products.

Primary energy: See energy units.

Process heat: Heat which is either used by or rejected by industrial processing operations. Process heat can be recycled as an alternative to using additional fuels. See district heating.

Quad: Quadrillion (10^{15}) Btu's -- see energy units.

Real price: A price which is measured relative to the prices of other goods and services, represented, for example, by the consumer price index.

Recovery methods: Various technologies for the production of petroleum (crude oil) from oil reservoirs, depending on the viscosity of the oil, the type of geological formation and the depth and natural pressures at which the recovery operations are applied. Recovery methods are categorized as either primary or enhanced. <u>Primary recovery</u> is the standard oil well production technique and yields approximately 20 per cent of conventional light crude oil but only 5 per cent of heavy crude oil from a reservoir, using natural pressure augmented by wellhead pumps. <u>Enhanced recovery methods</u> include secondary and tertiary techniques which increase the proportion of oil recovered, but at additional recovery costs. <u>Water flooding</u> is the best known secondary recovery technique, serving to supplement the natural pressures; yields up to 80 per cent of conventional crude oil and approximately 10 per cent of heavy crude oil from a reservoir. Water is pumped down "injection" wells forcing oil up through "producing" wells. <u>High-pressure live steam</u> (tertiary recovery) similarly injected will increase the heavy crude oil yield to approximately 20-40 per cent by reducing the viscosity and forcing greater volumes from the geological network into the producing wells. Steam stimulation is at the commercial threshold as a tertiary, "in situ" recovery technique for heavy crude oils in western Canada. <u>Wet</u>

combustion or fire-flooding techniques applicable to heavy crude oil reservoirs and deep oil sand deposits (over 1 000 feet depth) are presently at developmental stages, but at much higher cost. Fire-flooding requires the injection of air or oxygen to induce controlled combustion in the reservoir area, thereby increasing the temperature and lowering the viscosity of the heavy oils to facilitate recovery by pumping.

Renewables: Energy sources which are perpetual or replenishable; have life spans comparable to that of the solar system. Solar, biomass, geothermal, wind and hydraulic-river, ocean tides and waves are examples. See inexhaustibles.

Reserve: That portion of an identified fossil fuel resource from which a usable energy commodity can be economically and legally extracted at the time of determination, using currently available technologies.

Reservoir: Here refers to a site-specific part of an oil or natural gas reserve at which recovery operations are applied.

Residuals: That portion of the barrel of crude oil which remains after the refining process has extracted the lighter petroleum products. Residuals are marketed principally as asphalt and for the production of industrial process heat and for electricity generation.

Resource: All potential energy-producing natural phenomena and accumulations of naturally occurring substances which are known or inferred to exist (e.g. oil, natural gas, coal, uranium, hydraulic, peat and forest biomass).

Retrofit: Adding to a unit a device or materials for the purpose of enhancing the functional performance of the original unit.

Secondary energy: See energy units.

Slurry: A free-flowing pumpable suspension of fine solid material in a liquid. A slurry pipeline is one method of transporting coal.

SNG: Synthetic (or substitute) natural gas producible from naphtha, coal and biomass. Contains mostly methane.

Synthetic crude oil: The oil product obtained from upgrading (cracking) oil sands bitumen and heavy crude oils.

Solar energy: Energy in the form of solar radiation.

Thermal coal: Coal burned to produce heat, for example, for electrical generation and industrial processes; it will yield gaseous fuels by gasification processes and liquid fuels by liquefaction processes.

Utility: A company or institution which exists to provide specific services via contractual arrangements. Certain characteristics typify the public utility, as follows:

- Government approved or supported monopolies to supply continuous or repeated services between the plant of the supplier and the premises of the consumers.

- Control of its rates of charge for services is typically vested in public regulations which also limit maximum profitability.

- Regulations primarily protect the public in the role of consumers, rather than in the role of taxpayers who indirectly "own" the utility.

- There is a legal requirement to serve every financially responsible consumer in the service area, at reasonable rates and, within each class of service, without discrimination.

Wellhead: The location of primary extraction, usually of oil and natural gas. Also refers to the equipment used to maintain surface control of an oil or natural gas well and to various parameters as they exist at the wellhead, e.g. "wellhead price" applicable to natural gas and conventional crude oil production.

Energy units

Two forms of energy are referred to principally throughout this report:

Primary energy is the available energy content of the natural resource. Secondary energy is the amount of energy delivered to the final consumer. The difference between the two is the energy lost in conversion and in the process of supply. It should be noted that during the final end-use process additional losses occur at the point of final use. The energy in actual use is tertiary energy.

The unit of energy used most often in this report is the "quad" -- a quadrillion Btu's (10^{15}). Direct conversion can be made from quads to exajoules (10^{18} joules), within the limits of accuracy of the figures used in this report. (One quad is approximately equivalent to 1.05 exajoules.)

Approximately 1 quad of primary energy can be produced from

180 million barrels average gravity crude oil at 5.8 million Btu per barrel (approximately 500 000 barrels per day), or

50 million tons thermal coal at average 20 million Btu per ton, or

1 Tcf natural gas, or

80 million tons wood at average 12.5 million Btu per ton, or

29 GWh electricity at 10 000 Btu per kWh (rated at the generating facility). If the source is nuclear electricity, the amount of uranium which yields 1 quad of energy ranges from 1 600 000 kilograms uranium in CANDU reactors with a once-through cycle to 16 000 kilograms uranium in CANDU reactors with thorium cycles.

Btu - Amount of heat required to raise the temperature of one pound of water 1°F. 1 Btu = 1 055.056 x 10^3 joules (1 kilojoule).

Joule - Amount of heat required to raise the temperature of 1 gram of water 1°C.

Oil - 1 bbl (barrel) = 35 imperial gallons average gravity crude oil
= 5.8 million Btu.

- Average yield of products obtained from 1 bbl of crude oil by Canadian refineries in 1976, listed in ascending order of viscosity products to high:

per cent	product	No. imp. gallons
2	Petrochemical feedstock	0.7
36	Motor gasoline	12.6
18	Light fuel oil (LFO or No. 2)	6.3[1]
4	Jet fuel	1.4
12	Diesel	4.2
19	Heavy fuel oil (HFO or No. 6)	6.7[1]
3	Asphalt	1.0
6	Other	2.1
100	Total	35.0

1 Approximate energy content of 6 gal. is 1 000 000 Btu or equivalent to 1 Mcf natural gas.

Because of the dominant role played by oil, the rate of energy production is often expressed in terms of million of barrels of oil per day (MMbopd) or million of barrels of oil equivalent per day (MMboepd). Annual production at a rate of .5 MMbopd yields approximately 1 quad of energy in a year.

Natural gas

Mcf - One thousand standard cubic feet of natural gas.

Bcf - One billion standard cubic feet of natural gas.

Tcf - One trillion standard cubic feet of natural gas.

1 Tcf yields approximately one quad of energy.

Electricity

GW - Gigawatt is a unit of energy capacity, usually electrical energy (sometimes GWe (electrical) or GW_t (Thermal) 1 GW equals 1 billion watts (1 thousand megawatts, 1 million kilowatts).

GWh - Gigawatt hour is a unit of electrical energy -- 1 GW produced or consumed for one hour (1 GWh equals 1 million kWh).

kW - One thousand watts.

Load factor - Percentage obtained by dividing the average amount of electricity delivered in a period of time by the peak power delivered in that same period of time;

Capacity factor - Percentage obtained by dividing the average amount of electricity delivered in a period of time by the capacity available;

Uranium (U) - 1 tonne U = 2 200 pounds U = 1.3 short tons U_3O_8.

Average electricity yield from CANDU reactors is 0.06. GWh per kilogram of uranium containing U_{235} and U_{238} in the naturally occurring isotope ratio. Conversely, the uranium throughput in CANDU reactors is 130 tonnes per year per GW of electricity generated.

Appendix 2
STATISTICAL TABLES

Contents of statistical appendix

TABLE A.2-1

Sources of Canadian Primary Energy Consumption
(percentages)

	1950	1955	1960	1965	1970	1973	1974	1975	1976	1977p
Petroleum	29.8	45.7	48.6	49.4	48.1	47.3	46.3	46.8	45.7	44.7
Natural Gas	2.5	3.9	9.0	13.1	16.5	18.3	18.5	18.8	18.6	18.8
Coal and Coke	47.6	27.7	14.7	13.0	10.7	8.5	7.8	8.0	8.5	8.9
Hydro electricity	20.1	22.7	27.7	24.5	24.6	24.0	25.6	24.9	25.2	24.6
Nuclear electricity	-	-	-	-	0.1	1.9	1.8	1.5	2.0	3.0
Total Btu's (10^{12})	2 493	3 188	3 671	4 814	6 328	7 481	7 770	7 826	8 075	8 267

p: preliminary

Natural gas: 1 000 000 Btu's/Mcf

Hydro and nuclear electricity: 10 000 Btu's/kilowatt-hour

Source: EMR estimates

TABLE A.2-2

Canadian Secondary Energy Consumption
(percentages)

	1960	1965	1970	1973	1974	1975	1976p
Domestic and farm	24.4	22.9	20.8	19.1	19.8	19.8	19.7
Commercial	8.5	11.2	14.1	13.0	12.9	12.3	12.1
Industrial	34.3	33.1	32.2	33.7	33.8	33.0	32.9
Transportation	25.5	24.7	24.3	25.5	25.6	26.2	25.9
Energy supply industries (including pipelines)	7.3	8.1	8.6	8.7	7.9	8.7	9.4
Total Btu's (excluding thermal)	2 920	3 789	4 971	5 732	5 936	5 878	6 100
Thermal energy (Btu's X 10^{12})	119	323	528	639	635	681	707

p: preliminary

Electricity at 3 412 Btu's/kilowatt-hour

Source: Statistics Canada, Detailed energy supply and demand in Canada, Cat. No. 57-207

TABLE A.2-3

Petroleum Supply and Demand
(thousands of barrels per day)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977p
Supply										
Production										
Crude and equivalent	532.0	876.1	1 382.1	1 476.0	1 698.3	1 963.0	1 843.3	1 576.1	1 442	1 451
Gas plant liquefied petroleum gases	11.4	46.5	94.0	108.3	133.3	152.1	151.3	158.1	156	156
	543.4	922.6	1 476.1	1 584.3	1 831.6	2 115.1	1 994.6	1 734.2	1 598	1 607
Imports										
Crude	343.1	395.0	568.9	671.1	769.6	897.4	797.6	817.1	719	668
Refined products	96.2	162.5	193.3	158.6	147.9	123.6	86.5	42.1	36	58
	439.3	557.5	762.2	829.7	917.5	1 021.0	884.1	859.2	755	726
Total supply	982.7	1 480.1	2 238.3	2 414.0	2 749.1	3 136.1	2 878.7	2 593.4	2 353	2 333
Demand										
Domestic demand	860.0	1 144.6	1 466.3	1 516.5	1 621.1	1 711.2	1 728.1	1 720.4	1 777	1 802
Exports										
Crude and equivalent	113.0	295.6	669.8	750.8	951.3	1 138.6	910.9	707.4	470	325
Liquefied petroleum gases	-	21.1	57.0	64.4	85.5	98.9	100.2	99.8	115	127
Other refined production	9.9	8.6	36.2	52.1	116.9	149.8	137.0	92.1	56	81
	122.9	325.3	763.0	867.3	1 153.7	1 387.3	1 148.1	899.3	641	533
Stock change	(0.2)	10.2	9.0	30.2	(25.7)	37.6	2.5	(26.3)	(65)	(2)
Total demand	982.7	1 480.1	2 238.3	2 414.0	2 749.1	3 136.1	2 878.7	2 593.4	2 353	2 333

p: preliminary

Source: EMR estimates

TABLE A.2-4

Marketable Gas Supply and Demand
(billions of cubic feet)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977p
Supply										
Production	443.0	1 051.0	1 868.6	2 071.8	2 360.3	2 523.9	2 500.8	2 526.7	2 543.5	2 676.5
Imports	5.5	17.7	10.9	14.3	15.7	14.8	13.3	10.2	4.6	-
Total supply	448.5	1 068.7	1 879.5	2 086.1	2 376.0	2 538.7	2 514.1	2 536.9	2 548.1	2 676.5
Demand										
Net sales	320.7	575.5	924.0	1 008.6	1 154.4	1 239.0	1 323.5	1 330.6	1 367.4	1 469.2
Pipeline uses[1]	11.3	55.1	118.9	118.5	127.7	134.0	114.7	122.8	107.3	94.5
Exports[2]	109.8	404.7	780.2	912.2	1 009.7	1 027.9	959.0	946.9	953.8	999.6
Reprocessing	-	21.4	29.3	49.8	75.7	79.3	79.9	79.7	81.2	86.4
Stock change	6.7	12.0	27.1	(3.0)	8.5	58.5	37.0	56.9	38.3	26.8
Total	448.5	1 068.7	1 879.5	2 086.1	2 377.8	2 535.6	2 512.2	2 536.9	2 548.1	2 676.5

1 Includes pipeline fuel consumed in Canada to move gas for export, which has been excluded from projections of domestic requirements

2 Includes pipeline fuel consumed in USA to move gas to central Canada

p: preliminary

Source: EMR estimates

TABLE A.2-5

Coal Supply and Demand
(millions of short tons)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977p
Canadian production	11.0	11.5	16.6	18.4	20.7	22.6	23.3	27.9	28.1	31.6
Imports[1]	12.7	16.7	19.8	18.4	19.4	17.3	14.3	17.5	16.3	17.0
Domestic demand	22.5	25.8	28.3	27.9	26.7	27.6	27.4	28.4	31.4	34.1
Exports[1]	1.0	1.3	4.7	8.0	9.7	11.7	11.9	12.7	13.3	13.6
Net exports (imports)	(11.7)	(15.4)	(15.1)	(10.4)	(9.7)	(5.6)	(2.4)	(4.8)	(3.0)	(3.4)

1 includes coke

p: preliminary

Source: EMR estimates

TABLE A.2-6

Electricity Supply and Demand
(billions of kilowatt-hours)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977p
Canadian production	114	144	205	216	240	263	279	273	293	316
Imports	1	4	3	3	2	2	2	4	4	3
Domestic demand	109	144	202	213	232	248	266	265	284	299
Exports	6	4	6	7	11	17	15	11	13	20
Net exports	5	-	3	4	9	15	13	7	9	17

Source: EMR estimates

TABLE A.2-7

Canadian Trade in Energy Commodities (millions of dollars)

	1960	1965	1970	1971	1972	1973	1974	1975	1976	1977p
Crude oil and equivalent										
Exports	94.5	280.0	649.1	787.4	1 007.5	1 482.1	3 406.8	3 051.5	2 286.7	1 750.6
Imports	280.3	312.5	415.3	541.3	681.0	941.0	2 646.5	3 301.9	3 273.9	3 243.2
Balance	(185.8)	(32.5)	233.8	246.1	326.5	541.1	760.3	(250.4)	(987.2)	(1 492.6)
Refined products										
Exports	9.3	10.0	44.0	63.4	140.5	207.2	359.2	332.9	198.8	187.5
Imports	115.5	160.0	185.4	184.1	185.4	192.3	325.0	206.5	172.5	240.1
Balance	(106.2)	(150.0)	(141.4)	(120.7)	(44.9)	14.9	34.2	126.4	26.3	(52.6)
Liquefied petroleum gases										
Exports	0.0	10.8	37.5	46.0	62.9	93.1	244.2	300.8	350.0	448.6
Imports	0.0	0.8	1.8	1.0	1.3	2.3	2.3	2.3	3.5	2.8
Balance	0.0	10.0	35.7	45.0	61.6	90.8	241.9	298.5	346.5	445.8
Natural gas										
Exports	18.1	104.2	206.0	250.7	306.8	350.7	493.6	1 092.2	1 616.5	2 028.1
Imports	1.6	7.5	5.1	7.0	7.6	7.8	5.8	7.8	8.8	-
Balance	16.5	96.7	200.9	243.7	299.2	342.9	487.8	1 084.4	1 607.7	2 028.1
Coal and coke										
Exports	11.2	14.0	35.7	94.7	112.9	176.7	264.2	481.5	566.2	608.6
Imports	80.4	134.8	164.2	173.6	196.3	181.4	344.2	626.9	570.2	659.8
Balance	(69.2)	(120.8)	(128.5)	(78.9)	(83.4)	(4.7)	(80.0)	(145.4)	(4.0)	(51.2)
Electrical energy										
Exports	15.5	16.9	34.4	48.2	67.9	109.2	174.6	104.3	161.7	377.0
Imports	0.5	14.3	13.9	14.8	11.1	7.0	5.2	12.6	9.2	14.7
Balance	15.0	2.6	20.5	33.4	56.8	102.2	169.4	91.7	152.5	362.3
Radioactive ores										
Exports	0.0	53.7	26.0	17.7	40.1	64.2	54.9	47.1	67.3	76.3
Imports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Balance	0.0	53.7	26.0	17.7	40.1	64.2	54.9	47.1	67.3	76.3
Total										
Exports	148.6	489.6	1 032.7	1 308.1	1 738.6	2 483.2	4 997.5	5 410.3	5 247.4	5 476.7
Imports	478.3	629.9	785.7	921.8	1 082.7	1 331.8	3 329.0	4 158.0	4 044.7	4 160.7
Balance	(329.7)	(140.3)	247.0	386.3	655.9	1 151.4	1 668.5	1 252.3	1 202.7	1 316.0

p: Preliminary

Source: Statistics Canada, Imports and exports by commodities, Cat. Nos. 65-007 and 65-004

TABLE A.2-8

Oil and Gas Energy Use by Consuming Sector and Region of Canada - 1975

	Percentage of sector energy supplied by specified fuel						
	Res.	Comm.	Indust.	Trans.	Total Sec.	Electrical generation[1]	Barrels of oil equivalent /capita[2]
Oil							
Atlantic	84	74	61	100	84	46	39
Quebec	72	55	51	100	71	1	28
Ontario	50	16	32	100	48	1	21
Manitoba	35	13	29	100	49	1	20
Saskatchewan	48	7	13	100	48	1	26
Alberta	27	8	14	100	34	-	26
B.C. - Yukon and N.W.T.	42	30	37	100	53	5	24
Canada	55	29	31	100	55	5	25
Natural gas							
Atlantic	-	-	-	-	-	-	-
Quebec	6	8	12	-	6	-	2
Ontario	30	51	41	-	29	10	14
Manitoba	43	53	39	-	31	-	13
Saskatchewan	41	66	70	-	43	14	25
Alberta	61	72	75	-	60	43	53
B.C. - Yukon and N.W.T.	35	43	28	-	28	7	14
Canada	26	40	33	-	26	7	13
Oil and natural gas							
Atlantic	84	74	61	100	84	46	39
Quebec	78	63	63	100	77	1	30
Ontario	80	67	73	100	77	11	35
Manitoba	78	66	68	100	80	1	33
Saskatchewan	89	73	83	100	91	15	51
Alberta	88	80	89	100	94	43	79
B.C. - Yukon and N.W.T.	77	73	65	100	81	12	38
Canada	81	69	64	100	81	12	38

1 Fuel used to generate electricity assumed to be converted at 34.12 per cent efficiency
2 Includes all oil and natural gas purchased for the generation of electricity
Source: Statistics Canada, Detailed energy supply and demand, Cat. No. 57-207, 1975

TABLE A.2-9

Canadian Energy Capital Expenditures
(Five year averages and percentage shares)

Industry	1956-1960 MM$	1956-1960 per cent	1961-1965 MM$	1961-1965 per cent	1966-1970 MM$	1966-1970 per cent	1971-1975 MM$	1971-1975 per cent
Crude petroleum and natural gas industry	240.3	17.6	355.0	26.5	524.9	21.2	1 059.4	23.1
Petroleum and natural gas transportation systems	176.7	12.9	124.2	9.2	214.8	8.7	379.1	8.3
Petroleum refining and marketing	152.2	11.1	92.8	6.9	218.5	8.8	461.6	10.1
Natural gas utilities	69.7	5.1	70.7	5.3	100.7	4.1	157.5	3.4
Electric utilities	647.5	47.4	691.3	51.6	1 350.6	54.7	2 431.7	53.0
Coal and uranium mining	80.2	5.9	6.3	0.5	61.0	2.5	94.9	2.1
Total energy	1 366.6	100.0	1 340.3	100.0	2 470.5	100.0	4 584.2	100.0
Total economy	8 465.0		10 074.8		16 118.4		28 223.0	
Energy share (per cent)	16.1		13.3		15.3		16.2	

MM$ = million dollars

Source: Statistics Canada

TABLE A.2-10

Canadian Annual Energy Capital Expenditures, 1974-78

Industry	1974 MM$	1974 per cent change	1975 MM$	1975 per cent change	1976 MM$	1976 per cent change	1977 * MM$	1977 * per cent change	1978 * MM$	1978 * per cent change
Crude petroleum and natural gas industry	1 226.2	31.1	1 574.7	28.4	2 162.1	37.3	2 636.1	21.9	2 723.9	3.3
Petroleum and natural gas transportation systems	252.4	(32.9)	361.9	37.9	337.3	(6.8)	380.4	12.8	371.7	(2.3)
Petroleum refining and marketing	574.2	28.5	603.2	5.1	509.1	(15.6)	527.0	3.5	457.7	(13.1)
Natural gas utilities	191.7	31.0	192.7	0.5	182.3	(5.4)	216.2	18.6	220.7	2.1
Electric utilities	2 703.1	20.5	3 957.1	46.4	4 228.6	6.9	5 183.7	22.6	6 130.5	18.3
Coal and uranium mining	123.0	117.7	151.2	23.0	257.2	70.1	399.6	55.4	331.4	(17.1)
Total energy	5 080.6	20.4	6 840.8	34.6	7 676.6	12.2	9 343.0	21.7	10 235.9	9.6
Total economy	32 882.2	23.5	38 216.2	16.2	43 636.3	14.2	46 490.8	6.5	49 950.5	7.4
Energy share percentage	15.5		17.9		17.6		20.1		20.5	

* Preliminary estimates 1977, preliminary intentions 1978
Source: Statistics Canada

Appendix 3

SOURCES, METHODS AND STRATEGIC ISSUE AREAS

Source references are not given throughout the report, partly to avoid burdening the narrative, and partly because of the amount of assimilation and modification which was done to original material. Virtually no analyses or forecasts exist which carry assessments out to 2025 in ways relevant to this report. Much of the basic source material originated with published energy data and within Energy, Mines and Resources Canada, but much of it came from unpublished documents and the great number of interviews and from the assembly of other written material. For example, 20 departments and agencies of the federal government and officials of all 10 provincial governments, and provincial energy agencies were consulted. They provided substantial background material. A host of others from industry, labour unions, universities, research centres, econometric model experts, consumer and special interest groups, international agencies and consultants also were consulted. Three features of the study preparation bear special note:

- the use of task forces and reference panels;

- the preparation of assessment papers; and

- the matrix approach to major subject areas.

Task forces, reference panels, consultants and assessment papers

Ten task forces were established in the early, preparatory stages. They were made up mainly of officials of federal government departments who served as advisory groups on the subject matter areas shown in Figure A.3-1. In some instances, task forces were not formally organized but reference panels were called together for consultation with the energy review group. A number of the task forces produced reports for submission to the energy review group. Three other reports were commissioned from outside consultants. For two of these, the energy review group was a co-sponsor along with others. In addition, access as a client was available to the on-going Stanford Research Institute's World Energy Study. The reports of the task forces and of the commissioned consultants were designated "assessment papers" and classified as working papers to the LEAP program. The assessment papers and other sources are outlined briefly later in this appendix.

Strategic program approach

The study was conceived as outlining a comprehensive National Energy Program. It illustrates a more general <u>strategic sector</u> model approach which is applicable to all sectors of the economy and to their strategic relationships (for example, food, transportation, land use, manpower, financing, resource development

and upgrading, manufacturing, population distribution, income distribution, environment, regional development, and so on).

Within the Energy Sector, major subject areas were identified for task force consideration. Relevant to those principal subject components are strategic issue areas such as those of Chapter 6 of the report, and the principal National Energy Program activities and targets such as identified in Chapters 4, 6 and 13. These relationships are illustrated in Figures A.3-1 and A.3-2. Together, they form a substantial part of a comprehensive, integrated National Energy Program. Individual components and specific relationships can be proceeded with independently, but a nationwide appreciation of the objectives, targets and coordinated activities, within the comprehensive National Energy Program, will greatly enhance the contribution of the individual components.

The National Energy Program and the recommended actions of this report require systematic support activity. Some elements of the support activities are illustrated in this Appendix. They formed the basis for much of the analysis and of the broader conceptual framework. The revealed gaps and shortcomings strongly support the recommendation that the approach here touched upon be fully developed into a continuing, systematic Long-term Energy Assessment Program (LEAP) of which this report, designated LEAP 1978, would be simply a beginning. All support activities would then be greatly expanded around clearly perceived objectives. Task forces, mostly of volunteer participants with secretarial and management support, would function within each component of the illustrated energy matrix and the supporting strategic issue areas.

Energy matrix

The energy matrix of Figure A.3-1 contains major areas of investigation, each of which has cross-impacts with the others. When assessments in depth are made within one component of the matrix, the participants are required, in consultation with others, to assess the implications of those assessments for the other components of the matrix. The continuing assessments are related to the principal objectives, the long-term indicative targets, interim performance targets of the National Energy Program. The assessments are also made within the five feasibility criteria (gates or thresholds):

- resource availability;
- technological feasibility;
- economic viability;
- institutional capability; and
- social acceptability.

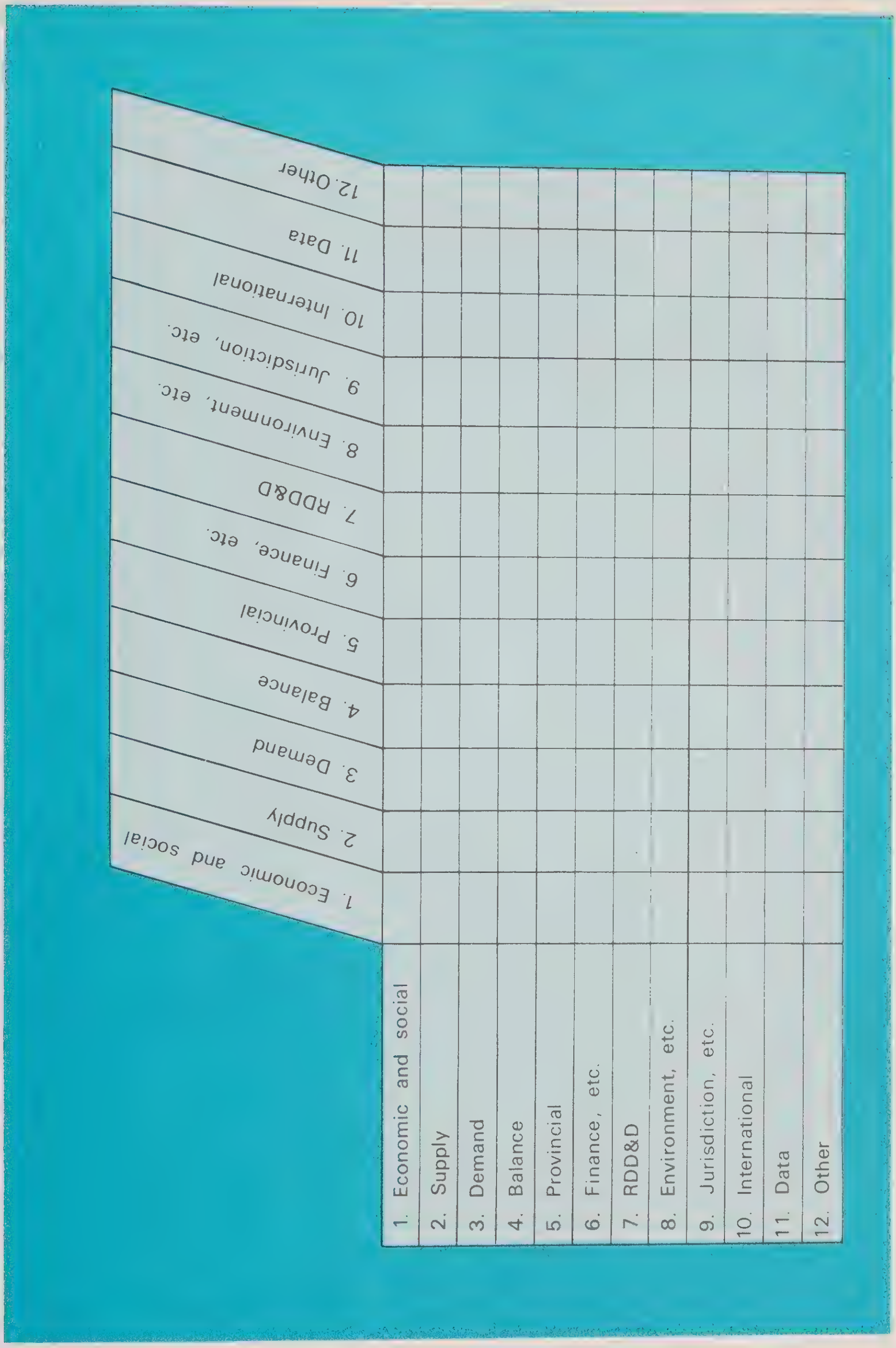

Figure A.3-1. Study matrix (task forces).

Any evolving energy program, therefore, would be assessed fully within all parts of the matrix, the strategic issue areas and the feasibility criteria. For this "Futures" report, the task forces which personified the matrix gave rise to background assessment papers. Such task forces and assessment papers, greatly increased in number, could constitute a method of continually updating the entire assessment program as a guide to, and an evaluation of, action.

Strategic issue areas

The strategic issue areas of Figure A.3-2 are designed to explore in greater depth, by studies, task forces, working groups, etc., the particular problem areas and opportunities which were identified by the task forces and others in the course of testing the feasibility of programs and targets. Within each strategic issue area, the bottlenecks, the gaps and the implications of change can be dealt with and the opportunities pursued. The perceptions and actions arising from each strategic issue area will permit widespread participation around subjects of individual interest and expertise (e.g. financing, environment, industrial efficiency, and urban design). It remains then to ensure that the communications process brings together, systematically and comprehensively, the results of the work done within the strategic issue areas. The full process of information and participation is designed to accomplish that objective.

Sources

Because studies were not available which covered the scope and time of this report, source material could be only partially supportive of some features of the study. The task forces and reference panels examined source material in their own areas of expertise and carried through assessments based on it. The energy review group, in consultation with the experts, synthesized those results and filled gaps by direct investigation. Although three studies were commissioned, there was not time for extensive, original research. Many high priorities for research were identified, but not met.

Source material can be considered in three categories:

1. Energy studies of Canada, historical and short and medium-term future, and support data.

2. Special studies within the LEAP program.

3. International and world studies.

It is not possible to list all sources that were referred to in (1) and (3). A brief description is given of sources by report chapters and a number of the principal reference sources are listed at the end of this Appendix.

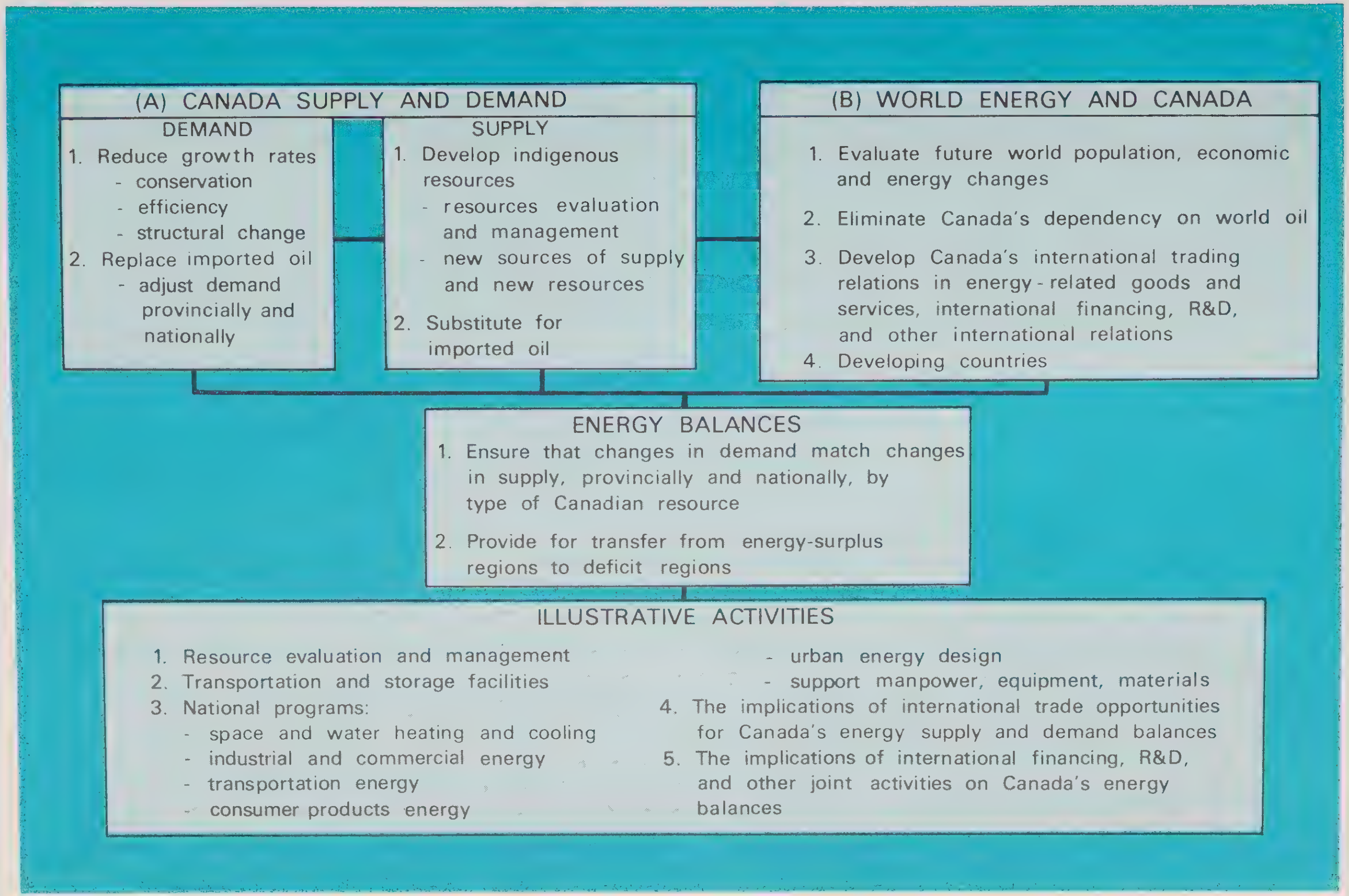

Figure A.3-2. Strategic issue areas.
I. Energy resources and their use — illustrative objectives and activities.

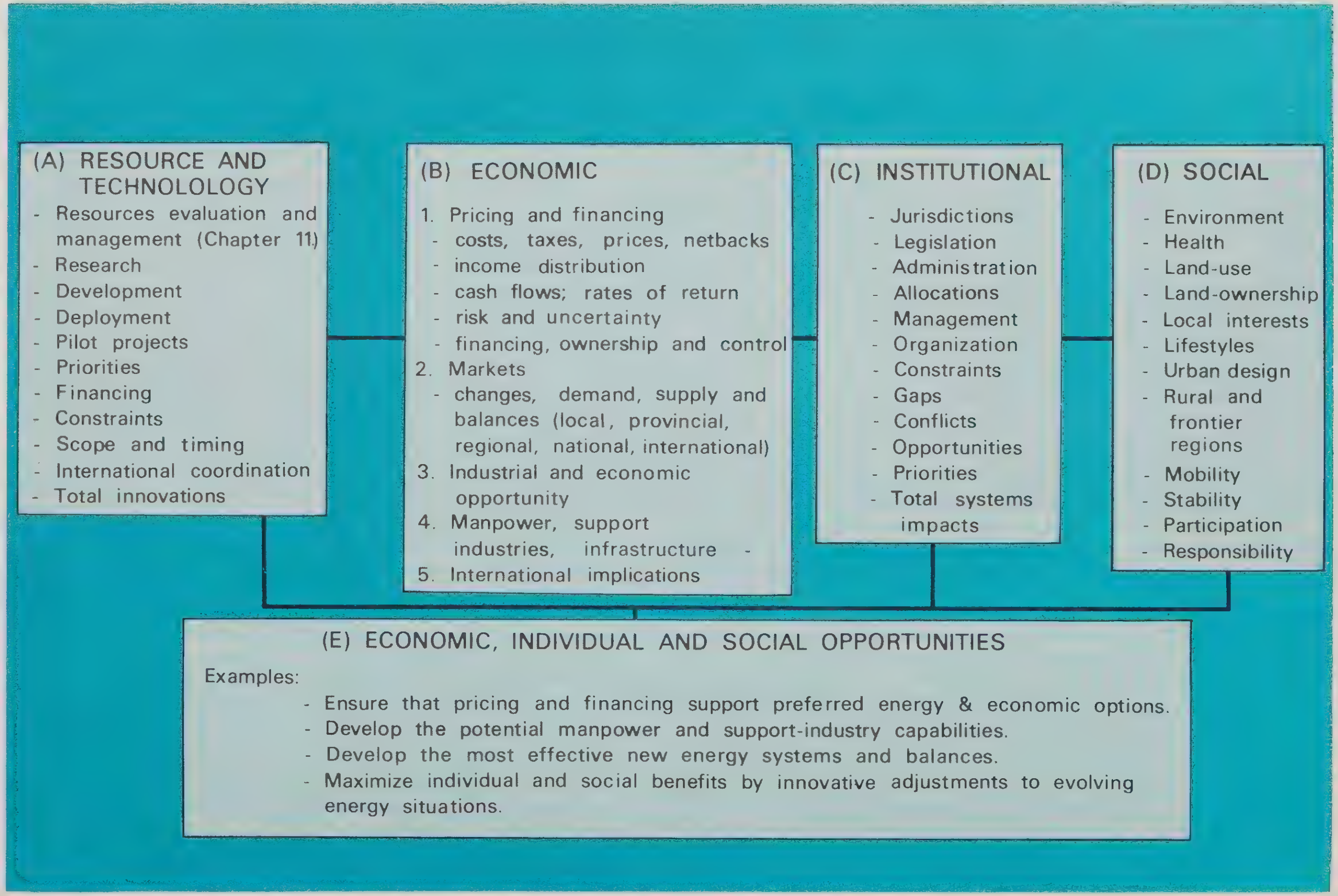

Figure A.3-2. (cont'd). Strategic issue areas.
II. Strategic adjustment factors.

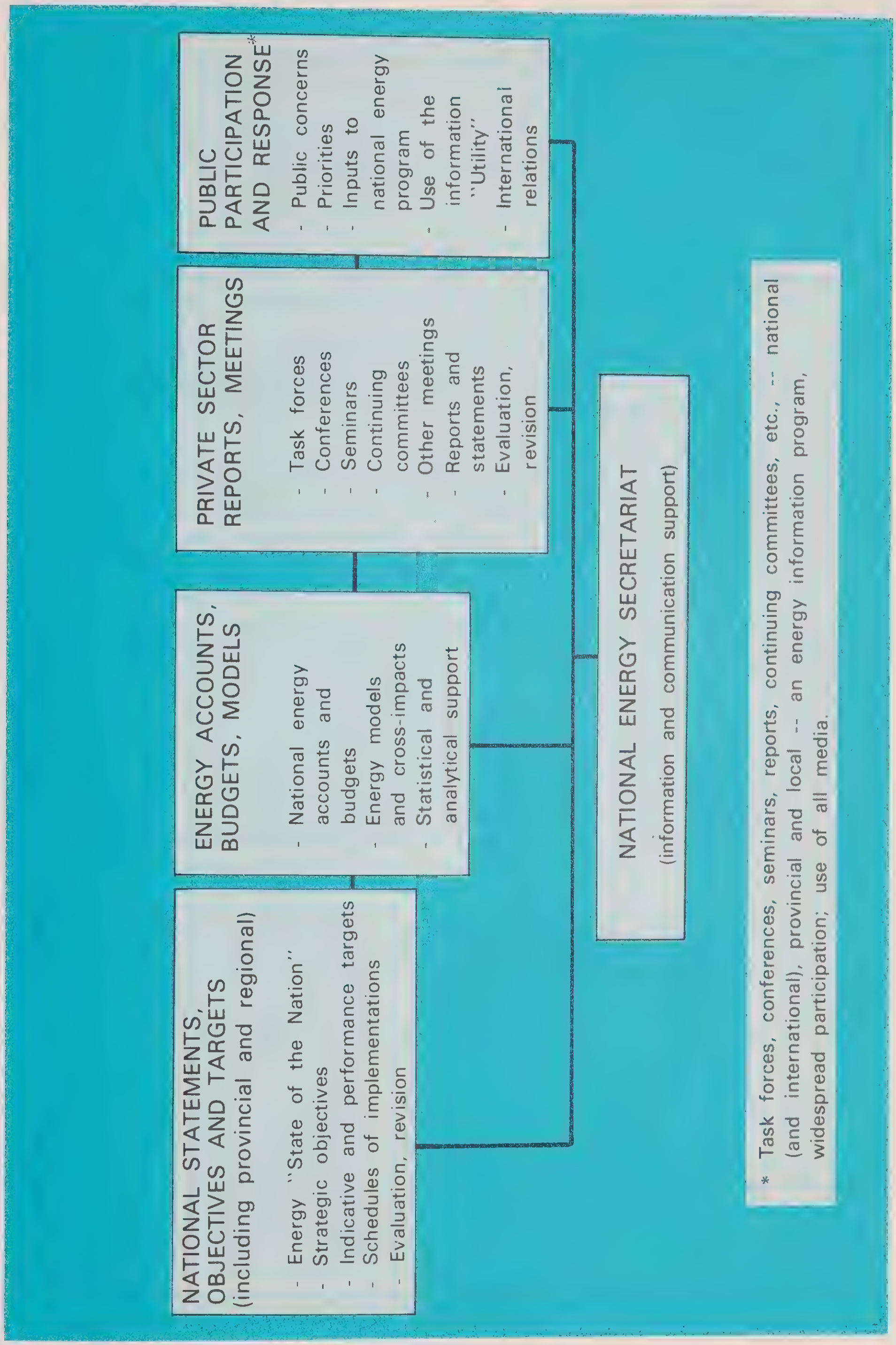

Figure A.3-2. (cont'd). Strategic issue areas. III. Information and participation.

Assessment papers

For (2) above, the principal special studies for the LEAP program took the form of assessment papers prepared by the task forces represented in the matrix of Figure A.3-1. Not all task forces produced a full assessment paper; in some instances, only memoranda and consultations were possible. The following are the principal assessment papers which were completed, or substantially completed:

1. World Energy Supply and Demand Analysis, 1973-2025; Van Meurs and Associates, Ottawa, 1978 (co-sponsored).

2. Some Scenarios of Energy Demand in Canada in the Year 2025; David B. Brooks, R. Erdmann and G. Winstanley; Report of the Demand and Conservation Task Force, 1977.

3. Towards a Long-term Energy Supply Strategy for Canada; Report of the Supply Task Force, 1977.

4. The Role of Technology in Canada's Energy Future; W.D. Bennett and P.J. Dyne; Report of the Technology Task Force, 1977.

5. Canada's Economic and Population Outlook; J. Gander and F. Belaire memoranda for the Economic and Social Task Force, 1977.

6. Canadian Energy Futures (an investigation of alternative energy scenarios, 1974-2025); John Robinson, et al., York University (a co-sponsored study); 1977.

7. 2025 Vision: Social and Economic Implications of Alternative Energy Futures: A Planner's View; Delphic Consulting Ltd., Victoria, B.C., 1977.

8. Energy and the Environment in the Long-term Future; Memoranda from the Environmental Task Force, 1978 (in conjunction with Fisheries and Environment Canada).

9. Co-generation; Working Paper; G.A. Robb, 1977.

Chapter documentation

Many chapters of the report rely on interviews and memoranda rather than on published studies which, for the most part, do not exist. The following note indicates, from the above assessment papers and the following other principal sources, some of the chapter sources. In almost all cases, extensions or adjustments have been made to source material for purposes of the report.

Chapter 2 - World Energy Futures - based mostly on data from the van Meurs' study (39), with reference to other sources in (C) below and other documents and interviews. The van Meurs' report contains a world population appendix based principally on United Nations' sources.

Chapter 4 - Energy Demand - based mostly on assessment paper (2) -- Scenarios of Energy Demand -- and Assessment Papers (6) and (7). The economic and population estimates are based on work done for assessment paper (5) which, in turn, relied heavily on sources papers (3), (9) and (18). A number of other source documents are relevant including, for example, sources (1), (2), (4), (14), (16), (17) and (22).

Chapter 5 - Energy Supply - based mostly on assessment paper (3) and follow-up evaluations arising from it, supported by the material represented by sources (24) to (38) inclusive.

Chapter 7 - The Provinces - based mostly on personal inverviews in each province and documentation assembled in the course of, or as a result of, the interviews and other contacts. The material is represented by sources (19), (20), (21), (28) and (29).

Chapter 10 - Finance, Ownership and Control - the task force on finance overlapped with the production of the report on Financing Energy Self-Reliance, source (5). That report was supplemented by the task force and, for example, by sources (6), (7), (13) and (15).

Chapter 11 - Research and Development - this chapter relied heavily on the task force report -- assessment paper (4) -- supporting work by the task force and from within the demand and supply components of the matrix. Much of the international literature also was relevant.

Chapter 12 - Environmental and Social - although the environmental task force did not complete an assessment paper, much of the documentation came from members of the task force represented under assessment paper (8). Other relevant material is illustrated by sources (10), (11), (12) and (33). Some of the international literature was also relevant.

Other principal references[1]

- See assessment papers above.

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1 The list cannot do justice to publications by provincial governments, agencies and utilities; universities and other research centres, or the international literature.

(A) Canada: Energy, economic and statistical, general

1. An Energy Policy for Canada, Phase I, Department of Energy, Mines and Resources, Ottawa, 1972 (2 volumes).

2. An Energy Strategy for Canada, Policies for Self-Reliance, Energy, Mines and Resources Canada, 1976, and "Energy Update", 1976 and 1977; Report EI 78-2.

3. Energy Demand Projections, A Total Energy Approach, Energy, Mines and Resources Canada, Ottawa, 1977; Report ER 77-4.

4. Energy Conservation in Canada: Programs and Perspectives; Energy, Mines and Resources Canada, Ottawa, 1977; Report EP 77-7.

5. Financing Energy Self-Reliance, Energy, Mines and Resources Canada, Ottawa, 1977; Report EP 77-8.

6. The Availability of Capital to Fund the Development of Canadian Energy Supplies; Canadian Energy Research Institute, Calgary; November 1977; Study No. 1.

7. Canada's Resources and the National Interest; Independent Task Force on the Crisis in the Development of Canada's Mining and Petroleum Resources; Report for the Canada West Foundation, Calgary, January 1977 (three volumes and summary).

8. "Into the 1980s" - Economic Council of Canada, Fourteenth Annual Review, 1977.

9. Simulations with CANDIDE to the Year 2000; B.L. Eyford and Bobbi Cain, Economic Council of Canada; Discussion Paper No. 89, Ottawa, 1977.

10. Northern Frontier, Northern Homeland; The Report of the Mackenzie Valley Pipeline Inquiry (Justice Thomas R. Berger); (two volumes), 1977; Department of Supply and Services Canada.

11. Reasons for Decisions, Northern Pipelines; National Energy Board, Ottawa (four volumes), 1977.

12. Alaska Highway Pipeline Inquiry (K.M. Lysyk, Chairman), Department of Supply and Services Canada, 1977.

13. "The Canadian Energy Situation in 1990 and Beyond"; Proceedings of the Canadian National Energy Forum; Canadian National Committee of the World Energy Conference; Halifax, 1977.

14. Canada's Energy Opportunities; Science Council of Canada, Report No. 23, Ottawa, 1975 (and other Science Council publications -- e.g. Canada as a Conserver Society, Report No. 27, September 1977).

15. Tax Policy, Energy Demand and Economic Growth, Ernst R. Berndt; Resources Paper No. 11; University of British Columbia, Vancouver (and other resources papers by the Department of Economics).

16. Detailed Energy Supply and Demand in Canada, Statistics Canada, Ottawa, Catalogue No. 57-207 (various years).

17. Trade of Canada, Imports and Exports, Statistics Canada, Ottawa (various years).

18. Population Projections for Canada and the Provinces, 1972-2001, Statistics Canada, 1974; Catalogue No. 91-514 (and other population and household and family statistics and projections, e.g. Catalogue No. 91-517).

19. Energy in Ontario, The Outlook and Policy Implications (two volumes); Advisory Committee on Energy (John J. Deutsch, Chairman); Government of Ontario, Toronto, 1973.

20. British Columbia's Energy Outlook, 1976-1991 (two volumes); British Columbia Energy Commission, 1976.

21. Saskatchewan's Proposal for a Canada Energy Security Fund, 1975; Government of Saskatchewan.

22. Energy Requirements Associated with Selected Canadian Energy Developments; G. Winstanley, Brian Emmett; et al.; Research Paper No. 13; Office of Energy Conservation, Energy, Mines and Resources Canada, Ottawa, 1977.

23. A Design Framework for Long-term Energy Economic Analysis of Dwelling Related Demand, Statistics Canada, Ottawa, 1977.

(B) Canada: Energy resources

24. Canadian Oil Supply and Requirements, National Energy Board, Ottawa, February 1977.

25. Canadian Natural Gas Supply and Requirements, National Energy Board, Ottawa, April 1975.

26. Oil and Natural Gas Resources of Canada, 1976; Energy, Mines and Resources Canada, Report EP 77-1, 1977.

27. Oil Sands and Heavy Oils: The Prospects; Energy, Mines and Resources Canada, Report EP 77-2; 1977.

28. Reserves of Crude Oil, Gas, Natural Gas Liquids, and Sulphur; Province of Alberta; December 31, 1975; Energy Resources Conservation Board, Calgary (and other AERCB publications).

29. 1977 Petroleum and Natural Gas Price and Incentive Hearing; British Columbia Energy Commission, Vancouver, 1977.

30. 1976 Assessment of Canada's Coal Resources and Reserves; Energy, Mines and Resources Canada, Report EP 77-5, 1977.

31. 1976 Assessment of Canada's Uranium Supply and Demand; Energy, Mines and Resources Canada, Report EP 77-3 1977.

32. Optimization of CANDU Reactors for Industrial Energy Supply; J.T. Rogers, Energy Research Group, Carleton University, Ottawa, 1977 (and other papers by the Energy Research Group).

33. The Management of Canada's Nuclear Wastes; report prepared for the Minister of Energy, Mines and Resources Canada; A.M. Aikin, J.M. Harrison and F.K. Hare (Chairman), 1977; Report EP 77-8.

34. Renewable Energy Resources, A Guide to the Literature; Energy, Mines and Resources Canada, Report EI 77-5, 1977.

35. Implementing Solar Energy Technology in Canada, The Costs, Benefits, and Role of Government; Energy, Mines and Resources Canada, Report EI 77-7, 1977.

36. The Potential for Solar Energy for Canada; Conference of the Solar Energy Society of Canada, Inc., Ottawa, 1975.

37. Canada's Renewable Energy Resources, An Assessment of Potential; Middleton Associates, Toronto, 1976.

38. Solar Heating in Canada, Problems and Prospects; Harold D. Foster and W.R. Derrick Sewell; Fisheries and Environment Canada, Office of the Science Adviser, Report No. 16, 1977.

(C) Other country and international

39. World Energy Supply and Demand Analysis, 1973-2025; van Meurs and Associates Limited, Ottawa (three volumes), 1978.

40. Energy Global Prospects, 1985-2000; Workshop on Alternative Energy Strategies (WAES); McGraw-Hill Book Company, New York, 1977.

41. International Energy Prospects to 2000, Petro-Canada, Petroleos de Venezuela.

42. Towards an International Strategy for Energy Research and Development; International Energy Agency, (OECD), September 1977; Paris.

43. 1977 SLT Country Review, Part 1, IEA, GB (78) 8.

44. Summary Report on Energy Prospects in Non-IEA Countries 1975-2000, IES (78) 19.

45. World Energy Outlook, Exxon Corporation, 1978.

46. World Energy Prospects Federal Energy Administration, U.S.A., June 1977.

47. Annual Report to Congress, Energy Information Administration, U.S. Department of Energy, 1977 DOE/IEA - 0036,2) (and other U.S. Department of Energy reports).

48. The Outlook for World Oil into the 21st Century, Petroleum Industry Research Foundation Inc. NY/NY.

49. Energy Demand Models of the World Bank, Bou M. John Choe and Charles Blitzer, May 1978.

50. Lorendas Model (Long Range Energy Development and Supplies) Virginia Polytechnic Institute.

51. Long Range Energy Prospects, Hendriks Houthakker, Harvard University, May 1978.

52. International Petroleum Encyclopedia, 1976; The Petroleum Publishing Co., Tulsa, Oklahoma, 1976.

53. Sourcebook for Energy Assessment, December 1975; M. Bellen, Editor; Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York (and other Brookhaven papers).

54. Assessment of Future National and International Problem Areas, Vol. I; Centre for the Study of Social Policy; Stanford Research Institute, California, 1977.

55. The Study of the Future: An Agenda for Research, National Science Foundation, Washington, 1977.

56. Energy in Transition, A Report on Energy Policy and Future Options; Secretariat for Future Studies, Sweden, 1977.

57. Energy Strategy: The Road not Taken? Amory B. Lovins; Foreign Affairs, October 1976.

58. Energy in the Future, Palmer C. Putnam, D. Van Nostrand Company, New York, 1953.

59. A Time to Choose, Ford Foundation, Energy Policy Project; Ballinger, New York, 1975.

60. An Inquiry into the Human Prospect, R. Heilbroner; Norton, N.Y., 1974.

61. Petroleum 2000; The Oil and Gas Journal; Tulsa, Oklahoma, August 1977 (and other issues of the Journal).

62. The International Energy Situation: Outlook to 1985; Central Intelligence Agency, Washington, 1977.

63. Proceedings of the Intergovernmental Meeting on the Impact of the Current Energy Crisis on the Economy of the ESCAP Region (Economic and Social Commission for Asia and the Pacific); United Nations, New York, 1974.

64. Thermal Energy Storage, Report of a NATO Science Committee Conference, Belgium, 1976.

65. World Energy Supplies, 1970-1974; United Nations, New York, 1975 (and other United Nations' publications).

66. International Statistical Year, 1973; Organization for Economic Cooperation and Development; Paris, 1976 (and other OECD publications).

67. OPEC Oil Report, Petroleum Economist, Geneva, Switzerland, 1977.

68. ManKind at the Turning Point: Second Report of the Club of Rome; M. Mesarovic & E. Pestel; Dulton, New York, 1974.

69. Social Limits to Growth, F. Hirsch; Harvard University Press, Cambridge, Mass., 1977.

70. Small is Beautiful: Economics as if People Mattered; E.F. Schumacher, Harper & Rowe, New York, 1973.

71. The Entropy Law and the Economic Process, Georgescu-Roegen; Business Week, March 24, 1975 (comment on the author's book of that title; Harvard University Press, Cambridge, Mass., 1971).

72. World Energy: Looking ahead to 2020; World Energy Conference; IPC Science and Technology Press, London, 1978.

Appendix 4

FROM ENERGY "STRATEGY" TO ENERGY "FUTURES"

Contents

An Energy Strategy for Canada 1976 — A summary[1]

The national energy strategy that the federal government has adopted is directed at minimizing our dependence on imported oil. The objective of the strategy is energy self-reliance.

In support of the self-reliance objective, the Government of Canada has identified nine major policy elements and has adopted a number of specific energy-related targets. The policy elements are:

- appropriate energy pricing;
- energy conservation;
- increased exploration and development;
- increased resource information;
- interfuel substitution;
- new delivery systems;
- emergency preparedness;
- increased research and development; and
- greater Canadian content and participation.

The major energy-related targets adopted by the Government of Canada for 1985 are:

- to move domestic oil prices towards international levels; and to move domestic prices for natural gas to an appropriate competitive relationship with oil over the next 2-4 years;
- to reduce the average rate of growth of energy use in Canada, over the next 10 years, to less than 3.5 per cent per year;
- to reduce Canadian net dependence on imported oil in 1985 to one-third of our total oil demands;
- to maintain self-reliance in natural gas until such time as northern resources can be brought to market under acceptable conditions; and
- to double, at a minimum, exploration and development in the frontier areas of Canada over the next three years, under acceptable social and environmental conditions.

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1 An Energy Strategy for Canada; Policies for Self-Reliance, Energy, Mines and Resources Canada, Ottawa, 1976.

Implementing the energy strategy

Initiatives to adjust to the evolving energy situation are being undertaken by all principal participants. Some recent and planned actions by the federal government are discussed here to illustrate progress in implementing the energy strategy. A key objective of that strategy was to reduce our net dependence on imported oil in 1985 from a forecasted 40 to 47 per cent to one-third of our total oil demand. In October 1977, this target became part of Canada's commitment to the international energy program, and was re-expressed as one-third of our total oil demand, or 800 000 barrels per day, whichever is less. The other policy elements and targets are directed primarily at achieving that objective. In this Appendix, the current initiatives are classified according to the policy elements of the energy strategy.

Appropriate energy pricing

FED./PROV. OIL PRICE AGREEMENT

The Strategy report emphasized that the appropriate pricing of Canadian crude oil and natural gas supplies is fundamental to the objective of energy self-reliance for Canada. In this context "appropriate" meant pricing at levels which would foster an adequate supply from domestic sources, dampen demand and provide a reasonable return to the resource-owning provinces. For oil, the target is to move Canadian crude oil prices towards international replacement cost levels. To this end, the price of Canadian crude oil has been progressively increased under a succession of federal-provincial agreements. Thus, the price of the average barrel of Alberta crude oil at the wellhead went up from $8 when the Strategy Report was published in the Spring of 1976 to $12.75 on July 1, 1978. These price increases, although greater than those occurring internationally, did not fully close the difference between Canadian and world oil prices. The average barrel of Alberta oil delivered to Montreal for about $13.50, whereas a barrel of overseas oil of about the same quality costs some $16 at mid-1978. Oil import compensation payments, in the amount of $2.50 per barrel, bring down the price of imported crude to parity with Canadian oil in central Canada. Consumers in import-dependent areas of Canada are thereby assured the same basic oil supply prices as consumers of domestic crude.

FED./PROV. GAS PRICE AGREEMENT

Successive Federal-Alberta gas price agreements have brought the price of natural gas delivered to the Toronto city-gate to about 85 per cent of the price equivalent of crude oil delivered to the refinery gate. The most recent of these agreements, effective August 1, 1978, provides for a gas price at that date of $2 per million Btu at the Toronto city-gate. At the 85 per cent gas-to-crude price relationship, natural gas is priced at its approximate commodity value in relation to oil products in existing gas markets in central Canada.

Energy conservation

CHIP AND HIP

FUEL ECONOMY STANDARDS

INDUSTRY TASK FORCES

FLIP

FISCAL MEASURES FOR CONSERVATION

Many conservation programs have been initiated in specific sectors such as residential buildings, transportation equipment, industries and consumer products. The major current programs are the Canadian Home Insulation Program (CHIP) and the Home Insulation Program (HIP) in P.E.I. and Nova Scotia. The Nova Scotia and P.E.I. programs involved the allocation of $80 million and $12 million, respectively. The CHIP program alone involves a commitment by the federal government of funding of $1.4 billion. Other conservation programs include preparation of an energy code for new buildings, fuel economy standards for automobiles (legislation's currently being prepared), the voluntary industry task force program, the industry energy bus program, across Canada, supplemented by consultant services in P.E.I. and Nova Scotia and the Industrial Energy Conservation R and D Program (IERD). More than $19 million was allocated in 1977 to the federal Office of Energy Conservation for the Federal Labour Intensive Program (FLIP) to staff energy conservation projects in four provinces. In addition, a number of fiscal measures have been taken, the two most significant being the 10 cent excise tax on gasoline (although this was not adopted primarily as a conservation measure), and the establishment of a special capital consumption allowance class within the Income Tax Act. This enables energy conservation equipment using municipal, wood or industrial byproducts to be fully depreciated over two years. Some sales taxes have also been removed from energy-conserving materials and devices, and special excise taxes have been imposed on automobile air conditioners and heavy automobiles.

CONSERVATION PUBLICATIONS

An extensive information program has been launched to promote conservation and increase public awareness of its importance.

In addition, a federal policy paper[1] explored the possibility of cutting the annual increase in the use of energy below the more general target of "less than 3.5 per cent". The report suggests that a 2 per cent growth rate is feasible, given the right combination of circumstances between now and 1990.

Exploration and development

OIL REVENUE SHARING

The combination of higher wellhead prices and provincial drilling incentives has resulted in a dramatic increase in exploration spending in western Canada. Oil and natural gas exploration and development expenditures in Canada during 1977 are expected to surpass the 1976 record of $1.2 billion. The federal formula for sharing new revenues as Canadian crude oil prices climb to world prices has contributed to this acceleration of exploration. The way in which an increase of $1 at the wellhead for Canadian crude oil is allocated between governments and private industry depends to a significant degree on the extent to which the industry increases its exploration spending (see Figure A.4-1).

It can be seen that if industry increases its exploration spending by 50 cents a barrel the federal share would fall from 27 cents to 3 cents on the dollar increase. If industry reinvested 57 cents per barrel in exploration, the federal share of additional production revenues could fall to zero.

FRONTIER TAX INCENTIVES

To encourage exploration and development in Canada's Arctic and eastern offshore areas, federal income tax measures provide incentives for reinvestment, allow deferment of tax payments through fast write-offs of the expenditures, and forego revenues through earned depletion.

REVENUE MONITORING

A proposed Petroleum Corporation Monitoring Act was introduced in Parliament in November 1977. The Bill is designed to provide assurances that revenue from increased oil and gas prices is being invested by industry in greater exploration and development in Canada. It would require companies to file semi-annual reports listing in detail all sources and disposition of funds.

1 "Energy Conservation in Canada: Programs and Perspectives", Department of Energy, Mines and Resources, Ottawa, 1977; Report EP 77-7.

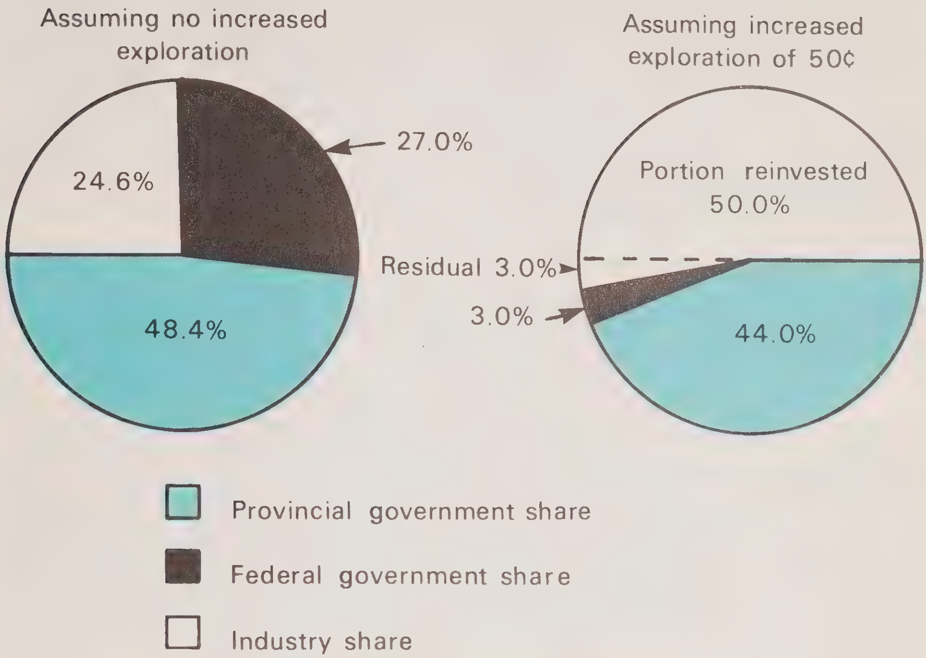

Figure A.4-1. Distribution of incremental net revenues from an increase of $1.00/bbl in crude oil.

WORLD PRICES FOR SYNTHETIC OILS

Amendments to the Petroleum Administration Act, which became law in April 1978, enable the government to designate high-cost domestic petroleum supplies as "imports" for purposes of the oil import compensation program. The output of Syncrude Canada Ltd. is the first source to be so designated. This procedure allows international prices to be conferred on selected new petroleum sources, while the general oil price in Canada is below world levels, in order to foster the development of such high-cost sources. This program is being financed by a levy on all oil processed and petroleum products imported for consumption in Canada, which became effective July 1, 1978.

TAX AID FOR ENHANCED RECOVERY

There were provisions in the April 10th federal budget to reimburse the cost of machinery and equipment and facilities for use in enhanced or "tertiary" recovery systems. These will be able to earn depletion allowances of $1 for each $2 expenditure as compared to the normal depletion allowance

of $1 for $3. (An enhanced recovery system is one that uses new technology to recover additional marketable oil from either conventional or heavy oil sands fuels. Depletion is a special allowance, deductible from taxable income, based on the eligible cost of recovering minerals and petroleum.) Secondly, the annual limit to which earned depletion could be used to reduce tax liability is raised for non-conventional oil projects, including new bituminous sand mining projects.

TAX AID TO OIL UPGRADING

Increased resource information

Certain actions have been taken with reference to oil, gas, coal and uranium in support of increasing resource information. In May 1976, the federal government outlined a proposed policy with regard to changes in Canada's Oil and Natural Gas Land Regulations. Enabling legislation -- the Petroleum and Natural Gas Act -- was introduced into Parliament in December 1977. This Bill will apply to about 1.3 billion acres of Crown reserve lands in Canada's northern and offshore regions. The Bill also allows ministerial discretion in terms of ordering drilling or production.

CANADA OIL AND GAS REGULATIONS

NATIONAL COAL POLICY

Work continued during 1977 on the development of a national policy on coal. A draft preliminary statement on the Canadian coal policy was discussed at the Energy Ministers' Conference held in Ottawa in December and more consultations are planned for 1978.

The federal and Nova Scotia governments agreed to spend up to $7.5 million for onshore and offshore coal exploration. A federal-British Columbia agreement provides for the expenditure of $10 million for geological, environmental, manpower, transportation and townsite information related to the possible development of coal deposits northeast of Prince George, British Columbia. Under the auspices of a federal-Saskatchewan agreement, that province's lignite resource evaluation program was completed.

FED./PROV. COAL EXPLORATION AGREEMENTS

The coal assessment group in the Department of Energy, Mines and Resources has developed programs for gathering the necessary data for reporting annually on coal supply along with pertinent data on quantity, quality and mineability, as well as economic information.

The coal assessment group is modelled on the previously established uranium resource appraisal group which produces annual assessments of Canada's uranium supply and demand. This group was organized to assist in the implementation of the new uranium policy for Canada announced on September 5, 1974. This program had two primary objectives:

URANIUM POLICY

- to ensure at least a 30-year reserve of nuclear fuel for all existing, committed and planned reactors in Canada in any 10-year forward period; and

- to ensure that sufficient uranium production capability is available for the Canadian domestic nuclear power program to reach its full potential.

A total of $4.8 million was spent on Canada's uranium reconnaissance program during 1977 by the federal government and participating provinces. Some 500 000 square kilometres were covered by air-borne gamma ray spectrometry and 250 000 square kilometres by regional geochemistry in areas of seven provinces, as well as the Yukon and Northwest Territories. Late in 1977 a new two and one-half year, $1 million program was announced to cover 166 000 square kilometres in Newfoundland and Labrador.

Interfuel substitution

The National Energy Board is responsible for ensuring that oil and gas exports are surplus to reasonably-foreseeable requirements for use in Canada. Pursuant to this mandate, the Board has a broad policy of phasing out exports of light crude oil and equivalent. The export rate for 1978 of some 55 000 barrels daily is less than 5 per cent of Canadian production of this grade of oil. Exports of heavy crude oil in 1978 are likely to be in excess of 100 000 barrels per day, that is roughly half of domestic production. Again, the outlook is for a progressive reduction in exports as domestic requirements of heavy oil increase, although the rate of phase-out will be less sharp than in the case of light crude oil.

EXPORT ONLY OF "SURPLUS" OIL AND GAS

The cut back by the National Energy Board in our exports of crude oil has been very rapid. In the first part of 1973, exports approximated 1 200 000 barrels per day while in the corresponding period of

1978 they were of the order of 200 000 barrels per day. These export cut backs have been much greater than the increase in domestic requirements for Canadian crude oil and the decline in crude-oil producing capacity. As a result, a large surplus of productive capacity has developed in western Canada.

No significant new exports of natural gas have been authorized since 1970. Exports have held steady since 1972 at a level of about 1 trillion cubic feet a year, approximately 40 per cent of Canadian production of marketable gas. With the advice of the National Energy Board, the government has acted periodically to ensure that Canada gets the best possible price for these remaining gas exports. As a result, their annual value has increased to approximately $2 1/2 billion.

SARNIA-MONTREAL PIPELINE

Interprovincial PipeLine's system was extended to Montreal in 1976, on the strength of federal financial guarantees. The 520-mile, $250 million Sarnia-Montreal extension delivers approximately 250 000 barrels per day of western Canadian oil to Canada's largest refining complex. In order to equalize oil supply costs between Toronto and Montreal-area refineries, the federal government subsidizes, at an annual cost of approximately $15 million, the movement of western oil between these two centres. At mid-1978, the federal government was actively considering measures to increase the use of Canadian oil at Montreal in order to improve our self-reliance, reduce oil import costs and associated compensation payments, and provide additional market for unused western Canadian producing capacity.

WESTERN GAS FOR THE EAST

Sharply-higher natural gas prices have been responsible for substantial increases in exploration in western Canada and a much-improved supply position. This situation provides the opportunity to expand markets for natural gas. New delivery systems to eastern Canada are in the planning stages, as noted below, along with pipelines to access frontier gas.

ELECTRICITY FOR IMPORTED OIL

MARITIME ENERGY CORPORATION

Another important element in interfuel substitution is encouraging the substitution of electricity from domestic energy resources, including nuclear, hydro and coal, for electricity generated from imported oil. This is a particular problem in the Atlantic region. The Maritime Energy Corporation is being formed to achieve optimal expansion and operation of electrical power generation in the Maritime

FUNDY TIDAL POWER

provinces. One of its tasks will be to manage a $33 million pre-feasibility design of a site in the Cumberland Basin to provide power from the Fundy Tides.

P.E.I. CABLE

The $36 million submarine cable interconnection between Prince Edward Island and New Brunswick for the delivery of electricity was completed and placed in service during the summer of 1977. This project is being supported by the federal government through grants and loans totalling $27 million. It will greatly reduce P.E.I.'s dependence on small thermal plants fuelled by imported oil. Loans totalling $14 million have been authorized to assist in the reinforcement of the New Brunswick and Nova Scotia electric interconnection.

N.S./N.B. GRID

LOWER CHURCHILL DEVELOPMENT CORPORATION

A joint federal and Newfoundland government program of evaluation of Labrador's hydro resources is currently underway. Early in 1978 an agreement in principle was reached to establish the Lower Churchill Development Corporation with equity shareholders being the Province of Newfoundland and Labrador and the Government of Canada. Its primary objective will be to establish a basis for the development of the hydroelectric potential of Labrador. First emphasis would be on the Gull Island project downstream from the Churchill Falls generating station, and the related transmission system to the Island of Newfoundland.

GULL ISLAND

POINT LEPREAU AND GENTILLY NUCLEAR PLANTS

The construction of nuclear power plants at Point LePreau, New Brunswick and at Gentilly in Quebec continued through 1977. These 600-megawatt plants are expected to be in service in the early 1980s. The federal government has made loans to New Brunswick and Quebec utilities to assist in the construction of these plants.

COAL CONVERSION

Under the federal R&D program, serious attempts have been made to encourage coal conversion by Canadian utilities. Funding commenced early in 1977 for a joint research and development program between the federal government, private industry and public utilities to substitute coal for oil and natural gas. The studies cover gasification and liquefaction of coal and new methods of burning coal.

RENEWABLE RESOURCES

Renewable resources, such as solar, wind, biomass, are receiving increased attention as potential substitute forms of energy. To coordinate these activities, Energy, Mines and Resources Canada has

RENEWABLE ENERGY AND CONSERVATION BRANCH

SOLAR

established a Renewable Energy and Conservation Branch. The federal government's energy research and development program is channeling the largest share of new R&D funds into projects on renewable energy resources. Some estimates indicate that by the year 2000, solar and other alternate resources could contribute the equivalent of 10 per cent of the total energy used by Canadians in 1975. In July 1978 the government announced a five-year, $380 million program to develop more energy from the sun, garbage and the forests. The solar energy package includes a federal purchase program, an assistance program to aid solar manufacturers and a design award competition.

PUSH

Purchase and Use of Solar Heating Program (PUSH) will spend $125 million on Canadian-made solar space and water heating equipment for new federal buildings. Since solar equipment is initially more expensive than conventional heating systems, the federal government will pay a premium on solar systems in the first year, a smaller premium in the second year, and so on. By 1984, there would be no subsidy, at which time solar equipment will be expected to compete on an equal footing with other types of systems.

PASEM

Under the Program of Assistance to Solar Energy Manufacturers (PASEM), up to 25 grants of $10 000 will be awarded to firms to prepare solar equipment design proposals. After assessment of these proposals, the government will make up to 10 contributions, of $200 000 to $300 000 each, to assist Canadian firms to design and develop solar heating equipment to meet the requirements of the PUSH program.

LEBDA

The Low-Energy Building Design Awards Program (LEBDA) will distribute $350 000 to the winners of a national competition for the design of more energy efficient buildings. Two competitions will be held, one for housing and the other commercial/industrial buildings.

INCREASED SOLAR RD&D

Funding for research, development and demonstration will be increased $2.5 million annually to bolster the current solar R&D budget of $9 million.

COST-SHARING AGREEMENTS

The federal government has also allocated $114 million to be spent under cost-sharing arrangements with provinces and the private sector for the demonstration of novel technologies or applications in the renewables and conservation areas.

BIOMASS

New federal government programs were announced in July 1978 to encourage large-scale development of energy from the forests and other forms of organic material, or biomass, as a substitute for oil, gas and even electricity.

The programs are as follows:

FIRE

Forest Industry Renewable Energy Program (FIRE) -- $143 million for the forest industry to use wood wastes as a fuel source instead of oil or gas. The program covers the period 1978-1985. In the longer term, investment of this kind should allow forest industry expansion as a producer of energy and chemical byproducts for home and export markets.

LOAN GUARANTEES

Biomass Energy Loan Guarantees -- Federal government guarantees for loans, worth a total of $150 million to assist in establishing electrical generating facilities using biomass as the energy source. This approach will encourage groups of industries, in cooperation with nearby communities and possibly provincial electrical utilities, to combine efforts on a local level to use wastes for electrical generation. Terms of the program will especially encourage co-generation of electricity and heat.

EXPANDED RD&D

Expanded Research, Development and Demonstration -- Approximately $40 million will be available from the federal government between 1978 and 1984 to help fund research projects and demonstrations of innovative techniques such as biomass plantations and the conversion of biomass to liquid fuels or chemicals. Federal-provincial cost-sharing will be the preferred approach to demonstration activities.

New delivery systems

In addition to the Sarnia-Montreal pipeline extension, a number of developments have taken place with reference to new energy delivery systems. The federal government, in August 1977, gave Foothills

ALASKAN PIPELINE

Pipe Lines (Yukon) Ltd. tentative approval for a natural gas pipeline for transmission of Alaskan gas across the Yukon, Alberta and British Columbia, with provisions for future interconnections with Mackenzie Valley gas. In late September 1977, Canada and the United States signed an agreement for the construction of this line.

POLAR GAS PIPELINE

Polar gas a consortium including TransCanada PipeLines, Panarctic Oils, Tenneco Oil Canada and

the Ontario Energy Corporation, applied to the National Energy Board on December 21st, 1977, to construct a 2 338 mile natural gas pipeline from the Arctic Islands to join the TransCanada Pipelines system at Long Lac, 150 miles north of Thunder Bay.

ARCTIC LNG

With some 13 trillion cubic feet of natural gas discovered in the High Arctic at the end of 1977, consideration is being given to moving some of it by sea to ports on Canada's Atlantic Coast. One such proposal is a joint venture of Petro-Canada and the Alberta Gas Trunk Line. Melville Shipping, a consortium of Canadian companies, is participating in the development and design of a transportation system. The project involves the construction and operation of a facility to transport 250 million cubic feet of natural gas per day from the Melville Island area to East Coast markets.

ARCTIC GAS COLLECTOR

Panarctic Oils, at Great Point on Melville Island, is developing a special pipeline system to carry natural gas to the islands from the experimental offshore well. The company expects the system to be completed early in 1978. At year's end (1977), Panarctic was also preparing to file an application for construction of a 112-mile pipeline from Great Point to Deeley Harbour, the site of the proposed gas liquefication plant.

IMPORTED LNG

In December 1977, Cabinet approval was given for National Energy Board licenses and certificates to three companies -- Tenneco LNG Incorporated of Houston, Texas; Lorneterm LNG, and TransCanada Pipe-Lines (New Brunswick) -- permitting the importation of Algerian liquefied natural gas by tanker at Lorneville, New Brunswick for vaporization and export to the United States via pipeline. One condition of the Tenneco license is that some gas be available for sale in Canada if terms and conditions are economic.

EASTERN EXTENSION OF GAS PIPELINES

During April, TransCanada PipeLines filed with the National Energy Board an application for certificate to extend transmission facilities to service more of the Quebec market. This would involve new transmission lines from the Ontario-Quebec border in two phases to Quebec City. There it would be tied into a proposed LNG terminal. An alternative proposal is being advanced by Alberta Gas Trunk and Petro-Canada which would involve moving western Canadian gas beyond Montreal to the rest of Quebec and the Maritimes.

NELSON RIVER TRANSMISSION SYSTEM

Agreement was also reached during 1977 to provide federal loans up to $193 million to assist the expansion of the Nelson River (Manitoba) transmission system to an ultimate capacity of 3 400 megawatts. The system is scheduled for completion by 1985 at which time federal funding will have totalled approximately $400 million, plus accumulated interest during construction.

Emergency preparedness

The Energy Strategy report noted that a major element in planning Canada's energy future must be an acceptable degree of emergency preparedness, in the event of possible curtailment of international oil supplies. As a participating country in the International Energy Agency's sharing scheme, Canada has agreed to: maintain oil stocks sufficient to sustain normal consumption for 82 days (90 days by 1 January, 1980) with no net imports of oil; maintain a contingency program of demand restraint measures; and be prepared to use these measures to meet the obligations of the international oil allocation system in an emergency.

MAINTAINING OIL STOCKS

EMERGENCY OIL STORAGE

Discussions are going on between Canada and the United States on the feasibility of developing eastern Canadian underground petroleum storage sites to hold a portion of the United States' strategic petroleum reserve. Individual sites have a capacity of up to 100 million barrels which is much in excess of foreseeable Canadian needs. Their development in this way could provide an opportunity for Canadian participation if and when required.

EMERGENCY ALLOCATION PLAN

The oil supply crisis of 1973-74 led to the passage of the Energy Supplies Emergency Act in January 1974, which created the Energy Supplies Allocation Board (ESAB) to prepare contingency allocation plans and carry them out if required.

The Act empowered the Governor-in-Council to declare a national emergency in the event of an actual or anticipated shortage of petroleum, or a disturbance in the petroleum market considered severe enough to affect the national security, welfare or economic stability of Canada, and to authorize ESAB to make and enforce regulations and priorities for the distribution of crude oil and petroleum products, including the rationing of gasoline, for the duration of such an emergency.

The Board's statutory life, for purposes of oil allocation, terminated June 30, 1976. Responsibility for maintaining petroleum emergency planning in an appropriate state of readiness now rests with the Energy Policy Sector of Energy, Mines and Resources, Canada.

Increased research and development

The federal government funding of energy research and development is now at the level of $145 million per year. Following the release of the Energy Strategy Report, $10 million was added to the R&D budget. New programs, especially in conservation and renewables, were introduced in recognition of the need for a long-term shift in emphasis. Since then, $25 million has been added to the federal energy R&D budget, about three-quarters of which is divided equally between funding renewable energy resources and the more efficient use of energy. The remainder is channelled towards substituting Canadian fuels for imported oil. The trend is indicated in the graph below showing the increases in energy R&D funding in the last and current fiscal year. Estimates of the total federal energy R&D expenditures during the last three fiscal years are set out in the table below.

TABLE A.4-1

Estimated Total Federal Energy R&D Expenditures (1977-79) by Subject

	1976-77		1977-78		1978-79	
	$000	per cent	$000	per cent	$000	per cent
Renewable energy	4 437	(4)	7 437	(6)	13 564	(9)
Energy conservation	8 025	(7)	11 396	(9)	16 716	(12)
Fossil fuels	12 326	(10)	13 826	(10)	15 226	(11)
Transportation and transmission of energy	5 218	(4)	6 182	(5)	7 432	(5)
Nuclear energy	90 028	(75)	90 028	(69)	90 288	(62)
Coordination and monitoring	160	(--)	1 025	(1)	1 238	(1)
	120 194	(100)	129 894	(100)	144 464	(100)

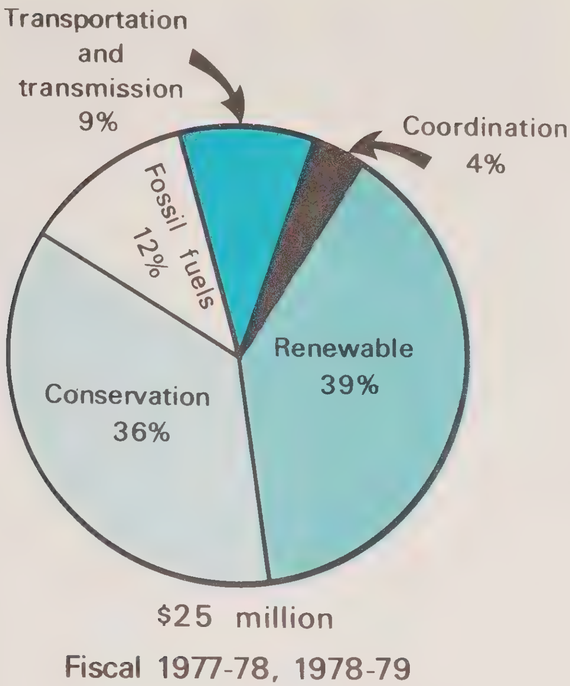

Figure A.4-2. Increases in federal research and development funds.

Greater Canadian content and participation

On December 20, 1977 the Canadian Government introduced the Canada Oil and Gas Act in the House of Commons. The Act, among other things, provides a preferential treatment for Petro-Canada in selecting Crown lands for exploration. The corporation was given the right to select up to 25 per cent of existing and future Crown lands for a period of seven years.

CROWN LANDS

Petro-Canada may acquire up to 25 per cent interest in land whose current tenure has expired without significant oil or gas discoveries having been made. This latter right would be diminished where permit holders have significant Canadian equity. It can be removed completely if the permit holder's Canadian equity is 35 per cent or more.

In 1976, the Government of Canada transferred its holdings in joint energy projects to Petro-Canada. These included a 15 per cent equity participation in

the Syncrude project; and a 45 per cent ownership of Panarctic Oils. The entry of Petro-Canada into exploration and development activities was facilitated by its purchase of all of the outstanding shares of Atlantic Richfield Canada Limited (ARCAN) for $340 million. Under its new name of Petro-Canada Exploration Incorporated, this Crown agency has been active in most of Canada's frontier regions including the Scotian Shelf region, the High Arctic, the Mackenzie Delta and onshore Northwest Territories. In its two years of operation Petro-Canada has spent $76.9 million in Canada's frontier regions excluding its involvement in Panarctic. The corporation's expenditures for exploration and development activity in western Canada has amounted to some $24.1 million from its inception to March 1978.

PETRO-CANADA

REVIEW OF FOREIGN INVESTMENT

Energy, Mines and Resources Canada plays an active role in the assessment of energy-related applications made to the Foreign Investment Review Agency (FIRA). Comments pertaining to whether or not new business establishments or take-over proposals by non-eligible persons comply with departmental policies are provided for each energy-related application submitted to the department by FIRA.

ENERGY FINANCING STUDIES

An important determinant of Canadian content and ownership is the capacity of Canadian industry to raise the capital necessary to finance the massive investment in manpower, materials and equipment that is necessary to achieve energy self-reliance. Earlier this year, Energy, Mines and Resources Canada released a background paper[1] which addressed the implications for the economy as a whole and the capital market effects of the energy investment program envisioned in the Energy Strategy report. The paper identified specific financing problems which might arise in each of the various energy industries. The study notes that under conditions of less than vigorous overall economic growth the financing of energy projects becomes more difficult, and would likely "be dependent on exports of a significant proportion of the additional energy produced". With specific reference to Canadian ownership and control of the petroleum industry, this study acknowledges the central role played by

1 Financing Energy Self-Reliance, Energy, Mines and Resources Canada, Ottawa, 1977; Report EP 77-8.

large multinationals in the past and the continuance of that role in the future. The study points out, however, that it may be necessary and desirable in the future to provide financing alternatives so that when intra-industry transactions take place, the weaker members will not find it necessary to surrender control and ownership of their discoveries and reserves, particularly to foreign interests.

A recent study by the Canadian Energy Research Institute supports the view that the financing to maintain future Canadian energy supplies is closely related to the health of the Canadian economy.[1] The report states that energy investment policies at the national and provincial levels have to be integrated with the country's overall economic policies, since the desired growth of energy supply will be more difficult to achieve and maintain in a poorly functioning Canadian economy.

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1 "The Availability of Capital to Fund the Development of Canadian Energy Supplies", J.R. Downs, Canadian Energy Research Institute, Calgary, 1977. (The Canadian Energy Research Institute is a cooperative research organization sponsored by four parties: the federal Department of Energy, Mines and Resources, the Alberta Department of Energy and Natural Resources, The Private Energy Research Association (composed of corporate and individual members from oil, gas, coal, electrical, nuclear energy and pipeline companies) and the University of Calgary. The objectives of the Institute are to develop an economic research capability and to conduct studies that will assist industry and government in dealing with energy problems.)

Energy Futures for Canadians — 1978 — A summary

This Energy Futures report is, in part, an extension through a longer time frame of the strategy assessment and current initiatives.

A National Energy Program is recommended to achieve sustainable self-reliance in energy by 2000 and then to maintain it. Five main policy elements are set down, each of which gives rise to a set of programs:

- transformation of end-uses (five recommended programs);

- consolidated energy supply (eight recommended programs);

- facilitate the adjustment process (seven recommended programs);

- realize economic and social opportunities (four recommended programs); and

- information and public participation (four recommended programs).

Supportive of the above policy elements are a number of indicative targets. These are:

- reduce the growth rate of energy demand for the period 1978 to 2000, to one-half the 5.3 per cent historic rate; cut the growth rate in energy demand in half again for the years 2000 to 2025;

- reduce the share of oil from 46 per cent of primary energy to 30 per cent by 2000, and 25 per cent by 2025, and reduce the share of imported oil to not more than 10 to 15 per cent of that lower oil share by the year 2000, and to a negligible amount by 2025;

- increase Canadian oil production by about 50 per cent by 2000, and sustain that level to 2025;

- increase natural gas production by at least one-third by 2000, and sustain that production, or increase it further, to 2025;

- increase coal production four or five times by 2000, with further substantial increases to 2025; extend the use of coal into many new applications;

- increase by one-half the share of electricity in total primary energy supplies so that electricity is providing at least one-half of total primary energy by 2025, compared to about one-third at present;

- by 2000, supply at least 5 per cent of primary energy from renewables (10 per cent by 2025);

- one-third of the energy requirements of central and eastern Canada to be supplied from within those regions, if possible by 2000;

- link energy transformation to new industrial, employment and international trade policies and to Canada's contributions to developing countries;

- energy prices in Canada to increase to world energy price equivalence, at least until the cost of energy production in Canada, for supplies adequate to meet long-term Canadian energy requirements, are below world price equivalence; and

- establish price differentials which promote economic substitution of indigenous energy resources in place of imported oil.

The policy elements and the indicative targets are supported by sets of programs, each of which has specific performance targets and recommended actions. The recommended programs are set out in Chapter 13. They include, for example, a national space heating program, an energy transportation program, an industrial energy program, a consumer product energy program, a community energy design program, a consolidated energy supply program dealing with oil, natural gas, coal, electricity, uranium-thorium nuclear, renewable resources and other energy resources, energy storage and transportation. A number of programs are directed at facilitating the adjustment process with particular reference to prices, financing, ownership and control, technological innovations, environment, health and other social objectives, institutional capability, and manpower, equipment, materials and infrastructural requirements. Another set of programs is targeted on achieving the economic and social benefits inherent in bringing about the energy transformations and in the subsequent use of that energy. Canada's potential comparative advantage in energy resources gives rise to new industrial and export opportunities with related employment, income, regional and community benefits. A national energy information and participation program would allow the integration of a vast array of decentralized, energy-related activities across the country to proceed around the objectives and shared purposes.

Beyond the current initiatives

Many initiatives are being taken by the federal and provincial governments, by industry and others, which contribute to the energy strategy for Canada. The "Energy Futures" study, while sharing the Strategy report perceptions of the next decade,

suggests an agenda for further, immediate action to deal with a very difficult, longer term future.

The Energy Futures assessment indicates that a fundamental transformation in Canada's energy system is required for the years beyond 1990. That transformation will be difficult in the extreme even if we make use of all available lead time. The transformation seems capable of achievement only with an approach which is characterized by:

- shared perceptions of the gravity of Canada's long-term energy future and of what to do about it;

- realization that the energy transformations require a comprehensive approach involving a set of indicative targets and coordinated action programs;

- conscious efforts to realize the economic and social opportunities inherent in the energy transformations; and

- extensive public participation and harmonization of efforts to render unnecessary preemptive central planning and control.

A National Energy Program is recommended to deal with the situations beyond 1990. It would extend current initiatives as outlined below.

Transform energy end-uses

Concerted action must begin right away, beyond current initiatives, to bring about substantial structural changes in energy end-use. For example, the national heating program is recommended so that local, indigenous energy resources may be thoroughly investigated and used, wherever economically justified, to meet the space heating requirements of that locality. Space heating requirements would be reduced to the lowest practical levels, not just by conservation measures but also by designed, structural changes -- new types of housing, new urban designs, new heating designs. The national heating program would include provision for how the remainder of the heating requirements are to be met in all localities and regions by other Canadian resources. In this way, the national heating program represents a <u>functional</u> approach to energy supply and demand. There are, at present, no comprehensive programs to deal with space heating in which both alternative fuels and different approaches to use are brought together into appropriate balances. The new balances are based on different combinations of resources, developed in various localities. In this instance, the objective is to meet essential, low-grade or low-temperature heating requirements from a variety of sources which are not now being fully utilized. The national heating program thereby is linked to the consolidated energy supply program and to other extensions of current initiatives.

Consolidate energy supply

The long-term energy future requires that programs be perceived within a comprehensive, national requirement. Each specific program would be evaluated in terms of its cross-impacts within the energy system and in terms of economic and social well-being more generally. Thus, the consolidated energy supply program looks at various interrelationships between each component part, such as the introduction of an additional gas supply, in relation for example, with the use of residual and heavy oil, tidal power, coal, or nuclear power, and in terms of the different combinations of energy end-uses which will appear in various parts of the country. The program is comprehensive not only in terms of direct energy combinations but also in terms of the decision-makers and the public who are an integral part of the program.

Achieve fundamentally different energy balances and facilitate the process of adjustment

The National Energy Program is based on bringing into place a fundamentally different combination of energy balances in a dynamic and ever-changing way. While all changes are incremental from a given starting point, the required perception is that a fundamental, long-term transformation is in progress. The incremental or ad hoc changes have specific positions in that whole, and the adequacy of their contribution can be continually assessed in terms of the perceived total requirements. For example, new balances would result in a substantially smaller role being played by oil, considerable efforts to retain the role of natural gas, a sizeable expansion of electricity in use in Canada. Much of the additional electricity would be provided by nuclear power and by coal. Additional uses of coal in gaseous and liquid form would also be assessed, as would its use to support activities such as the oil sands operations and industrial use of energy and feedstock requirements. Substantial efforts would be made to bring renewable resources into use with a well-defined assessment of their anticipated contribution and its timing. A shortfall anywhere in the total requires immediate efforts to meet the need by some other combination of effort. The energy balances also would reflect structural changes in energy use, in addition to programs for greater energy conservation and for greater efficiency in existing uses. The end-use transformations require a change in the nature of end-uses, not simply the more efficient or more effective performance of present uses.

Built into this approach to new energy balances are all of the elements, of adjustment -- high price and financing relations, environmental and land-use concerns, technological innovations, greatly altered institutions, regulations and management systems, and so on. The processes of adjustment are to be explicitly

addressed and brought together to render the process as smoothly efficient as possible. A particularly important element in the achievement of effective action is a thorough review of existing institutions, regulations, administrations and management systems as these are called upon to serve energy programs in a comprehensive, systematic way. These specific factors of adjustment are to be brought together to serve broader considerations, such as the perception of the long-term energy future, the comprehensive approach to it, the participation through information and communication programs, and action programs to extend and greatly alter the energy system.

These will result in new matchings of structural changes in end-uses to the new consolidated energy supplies.

Realize economic and social opportunities

All current initiatives are designed to ensure that Canada retains a satisfactory energy support for its economic and social well-being. A realization of the magnitude of change suggests that a wide range of economic and social opportunities can be explicitly achieved as part of the energy transformation. New patterns of energy use and new sources of supply will bring with them new forms of industrial and economic activity. In addition, Canada's new energy balances should permit it to compete more effectively in international markets, and have other international advantages. A third aspect of these benefits will be the development of management systems, systems of institutional and environmenal support, of technological innovation, of financing and for pricing energy resources that will produce a body of "intellectual property" which will be saleable in international markets. That proficiency can also be made available to developing countries to assist them in working out national energy programs or international, regional energy programs for their own benefit.

Shared perceptions and participation

Many of the programs to deal with the energy future must originate with the federal government and a considerable amount of the coordination to bring into place a National Energy Program will be the responsibility of the federal government. However, no program can succeed unless there are shared perceptions of the energy requirements and of how the new energy balances are to be brought into place. Hence, participation is to be brought about systematically in ways which enable all of the principal decision-makers who are concerned with energy and energy-related matters to view their priorities within the total program. In addition, members of the public can also see how their actions support a clearly perceived transformation of the energy system.

No comprehensive approach to Canada's long-term energy future can possibly succeed unless a well coordinated information, communications and participation capability is in place. All of the principal participants should begin with a common knowledge base even though they may differ in their interpretation of it. The information and participation program requires that publicly available national energy accounts be prepared, along with national energy budgets and national energy reports which will include global aspects of the world energy situation. Long-term indicative targets and short and medium-term performance targets serve as markers in a rapidly changing situation. Specific points of issue would be assessed by a two-way (or multi-way) flow of discussion and decisions among the interested parties. This information and participation program is perceived to be far more extensive and comprehensive than anything which is in place at the present time, even though considerable additional efforts have been made in recent years to build up a greater body of information and a greater sense of public involvement.

Conclusion

The current initiatives and the objectives which arose out of the Energy Strategy report can be greatly extended into additional programs designed to meet the situation beyond 1990. That situation cannot be described with any certainty. However, the required changes represent a fundamental and extremely difficult transformation. The actions which can now be put in place will serve as a basis for the energy transformations regardless of how they might differ from the perceptions contained in this Energy Futures report. A capability to act comprehensively and systematically on the longer-term future is not negated because the future cannot be described precisely. An essential feature of the additional activity is the establishment of indicative targets which set tentative flight paths along which the action will proceed. A process of continual evaluation and revision also is essential if the program is to retain the flexibility and the resiliency which the dynamic unfolding of energy events and of a changing society will require.